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In February, 1865, a change in the Federal comm before Charleston was again made, General Gillmore rel General Foster on February 9th.

On the 16th of February the commander of Fort S received orders to prepare to abandon the fort at on some 300 officers and men evacuated the work during the of February 17th, leaving it intact, according to instru And, it becoming known early the next morning that th had been evacuated, the fort was soon occupied by F troops, 250 guns falling into their hands.

The defense of Fort Sumter was ended.

COMMENTS

1. Between April 17, 1863, and February 17th, 186 fort was actually under fire some 280 days, and the cas in it incident to the bombardment were 267. The wei metal thrown, Johnson estimates as 3500 tons, of which 2400 tons represent the weight striking the fort.

2. We see in this struggle full use made of all me offense and defense—armored vessels, breaching guns harbor obstructions, including torpedo devices.

3. Fort Wagner was but an outwork and should been at the southern end of the island; it was lost becau attacking troops once obtained a foothold on the isla which it was located. Another example, only on a scale, of the affair at Roanoke Island in 1862. Moreov defense of Fort Wagner was too passive, no attempts made to drive the Federals off [illegible] no advantage being of the use of mort[illegible] the Federal siege oper difficult.

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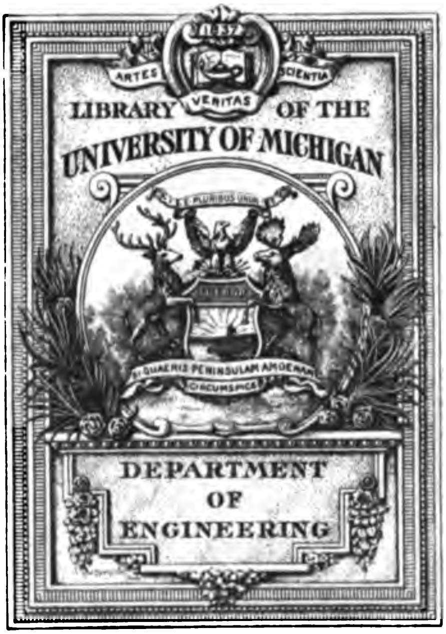

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JOURNAL

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UNITED STATES ARTILLERY

VOL. 42 No. 1 JULY—AUGUST, 1914 WHOLE No. 128

Honorable Mention, Essay Competition of 1913

THE MINE DEFENSE OF HARBORS: ITS HISTORY, PRINCIPLES, RELATION TO THE OTHER ELEMENTS OF DEFENSE, AND TACTICAL EMPLOYMENT

BY 1ST LIEUTENANT RAY L. AVERY, COAST ARTILLERY CORPS

HISTORY AND PRINCIPLES

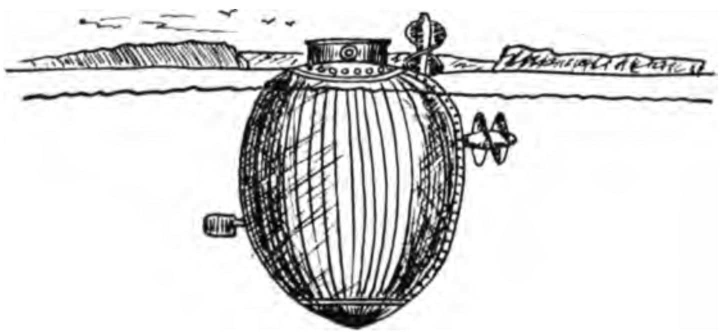
The earliest account that we have of the use of an apparatus in the least similar to the present submarine mine or torpedo, appears in the history of the siege of Antwerp in 1585. It was there an Italian engineer filled several small vessels with gunpowder, arranged a clockwork with triggers in their magazines, and floated the vessels downstream against a bridge which had been erected by the enemy.

His attempt at destroying the bridge was very successful and the effect of this novel mode of warfare caused further investigations along these lines. Not until the year 1775, however, was any real progress made. During the lapse of about two hundred years, from 1585 to 1775, the condition which is now recognized as necessary in submarine warfare, submergence of the charge, was overlooked. It is due to this fact that there was so long a pause in the progress of the new form of attack.

In 1775 David Bushnell, a native of Maine, proved that a charge of gunpowder could be exploded under water. He seems to be the first known investigator of underwater explosions, and to him is given the credit of inventing the first sub-

marine mine, or torpedo, as it was then called. To Bushnell is also given the credit of the first submarine boat, he having operated against the British 64-gun ship *Eagle* in New York harbor in 1776, with a submersible carrying a torpedo, which he hoped to attach to the bottom of the *Eagle* by means of a large wood-screw. He succeeded in reaching the man-of-war, dove, and began to attach the torpedo; but the wood-screw came in contact with some iron straps on the ship's bottom, and, due to the failure of air in the submersible at this time, the attempt was abandoned. The operator, believing he was about to be discovered, got away behind Governors Island.

Bushnell's next attempt was at Philadelphia in 1777, and is what is familiarly known as the "Battle of Kegs." Here he attacked the British shipping by floating kegs of gunpowder down the river to be exploded when they came in contact with



BUSHNELL'S SUBMERSIBLE. 1478

the ships' sides. Owing to the ships having been taken into the docks to avoid the ice which was then in the river, the attempt was unsuccessful, and the explosions which did result caused only confusion and alarm among the crews. In all his experiments Bushnell used mechanical means to cause ignition, generally employing clockwork which, when set in motion, would allow the operator to get clear before the explosion occurred. While Bushnell's investigations tended towards developing more efficient torpedoes, they do not seem to have been very successful from a tactical point of view.

The next man of prominence in the field of submarine mining was Robert Fulton, the American inventor. About 1797 he began a series of experiments in France with underwater charges of gunpowder, and in 1801 entirely destroyed a small ship in the harbor of Brest by means of one of his "sub-

marine bombs," which contained twenty pounds of powder—the first case on record of a ship known to have been sunk by a submarine mine. Fulton tried to interest the French Government in his experiments in order to obtain funds with which to continue them. He failed in this, however, because of his unsuccessful attempt to destroy one of the English channel fleet; so discontinuing his experiments in France, he went to England.

There in 1805 in the presence of numerous naval officers and scientific men he destroyed the British brig *Dorothea* off Dover, using two mines, each containing about 180 pounds of

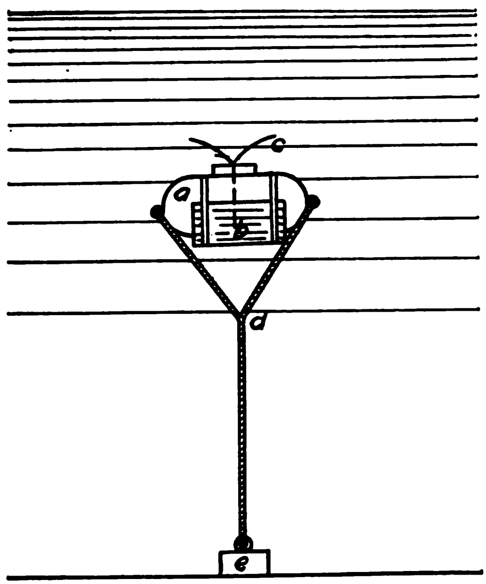


FIG. 1. 1479

black powder and fired by clockwork mechanism. Fulton, despite his apparent success, did not meet with much encouragement in England and in 1806 returned to America and laid his different schemes before Congress.

After repeated applications to Congress, a board was finally appointed to enquire into the feasibility of his projects. This board considered, among the various forms of torpedo presented, a stationary mine which was buoyant and intended for harbor defense. This mine consisted of a buoyant metallic case, to which was lashed a keg of powder, levers being arranged to release firing triggers when the mine was struck, and the

whole combination being moored under water to a heavy anchor. This was the first contact mine, and can safely be called the one to which the present day forms trace their origin. Fulton's efforts at home met with no more encouragement than they had met with abroad, and, after an unsuccessful attempt to torpedo the United States sloop *Argus*, he withdrew from the field of submarine warfare.

The following is an extract from the report of the board convened to investigate his experiments, taken from the documentary records of that period:

> It seems to be generally admitted that a ship may be destroyed by submarine explosions; but whether Mr. Fulton's system can be rendered practically useful, must as we conceive depend on future discoveries and improvements. The only opinion which we venture at this time to express, with any degree of confidence, is, that this system is at present too imperfectly demonstrated to justify the Government in relying upon it as a means of public defense. In expressing this opinion, we, however, disclaim the intention of attempting to discourage such investigations as the wisdom of Government, aided by other lights and information than we have possessed, shall consider fit and useful.

Fulton's opinion of the above report is given in his statement:

> Considering this subject from these various points of view, its infancy, its prospects of success, and, if successful, its immense importance to these states and to mankind, the small establishment, and inconsiderable sum required to practise and to prove its utility, compared with the expense of other nautical establisments which promise only common and imperfect results, I conceive it highly merits a patient and candid succession of experiments.

These extracts are included for the purpose of showing the opinion of those connected with the problem of harbor defense at that early date. While they are hardly favorable, they show the general tendency to be towards the further development of the submarine mine.

Fig. 1 shows Fulton's buoyant torpedo. The torpedo was made up of a metallic bouyant chamber (a) into the under side of which was fitted a keg of black powder (b). From triggers in the keg of powder a connection was made through the buoyant chamber to the levers (c). When these levers came in contact with any floating body they would be depressed, and in turn actuate the triggers, exploding the black powder charge. The whole combination was moored under water by means of the cable (d) and the anchor (e).

The withdrawal of Fulton marks the close of the first epoch in the development of the submarine mine. During this

epoch only mechanical means such as clockwork, levers, and triggers, were employed to fire the charges; and it is not strange that, with such crude methods, the attempts made against hostile vessels invariably failed.

The second epoch in the development of the submarine mine dates from 1829, the year marking the first experiments by Colonel Colt with a submarine electric battery.

Colonel Colt's first public demonstration was in New York harbor in 1842, when he successfully exploded an underwater charge of powder by use of a fuse fired by an electric current. Having proved that vessels at anchor could be sunk by means of electrical mines, he tried to destroy a vessel under way, using similar means. In this experiment the vessel was proceeding at the rate of five knots an hour, and several electric

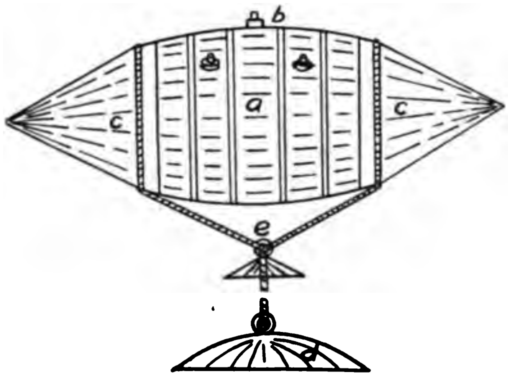


FIG. 2. 1480

contact mines were planted in her course. The experiment was successfully accomplished in 1843, and marks the beginning of the use of the electric mine.

From 1843 to our own Civil War there seem to be no records of particular note of submarine mine developments. In 1862, however, the Confederates tried to destroy some Federal gunboats in the Savannah River. From then on until the close of the Civil War both sides used mines, electrical and mechanical, with varying degrees of success. Chief among the successful operations was the loss of the *Commodore Jones* on the James River in 1864 by its coming into the destructive radius of an electrical mine containing 1750 pounds of gunpowder: and that of the Federal monitor *Tecumseh* at Mobile Bay on August 5th, 1864, when it struck a contact mine and went down almost immediately. Numerous other cases of

destruction or partial destruction of vessels from 1861 to1865 could be cited, but, owing to the like nature of the mines used in all cases, only the foregoing have been selected. Figures 2, 3, and 4 show the forms of Confederate mines most generally used.

Fig. 2 illustrates one of the first mechanical contact mines frequently used by the Confederates. This was made of a

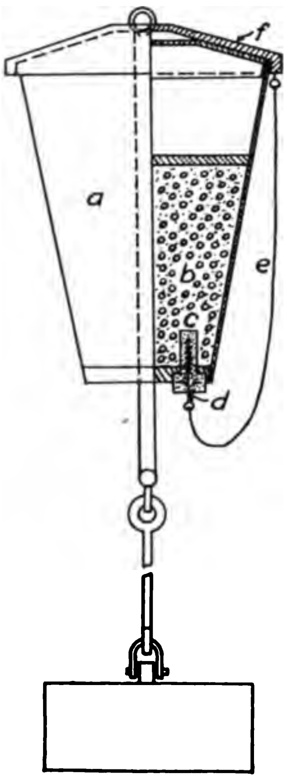


FIG. 3. 1481

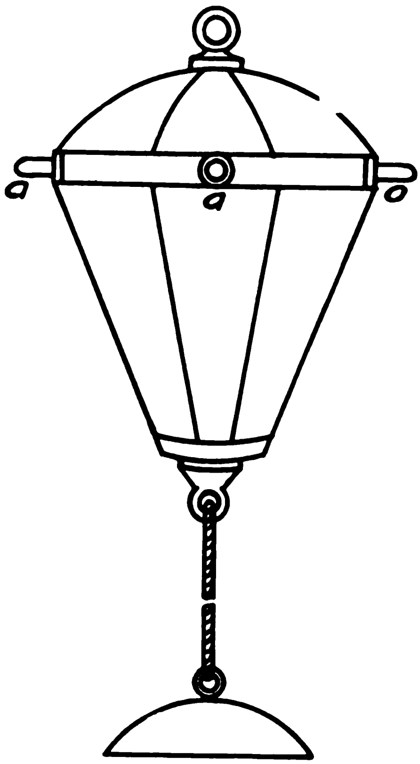


FIG. 4. 1482

barrel (a) containing a hundred pounds of black powder and exploded by means of percussion or mechanical fuses (b, b, b), generally five in number, set into sockets on each side and on top of the bilge of the barrel. Two cones made of wood were fastened to the ends of the barrel and kept the mine from swirling in the current. The mine was moored by the anchor (d) and kept upright at all times by a weight (e) fastened directly below the upper fuse opening. To make sure that the mine was watertight, it was coated both inside and out with pitch.

Another form of Confederate mechanical mine, a later development, is shown in Fig. 3. This mine was known as Singer's mine, and consisted of a buoyant metallic case (a), fitted with a compartment (b) filled with black powder. Into the bottom of this powder chamber was inserted a friction fuse (c), in which was placed a serrated wire (d) attached by a strong piece of metallic wire (e) to the cover (f). This cover rested on the top of the mine and was kept in place by its lower edge forming a lip around the top of the mine case. When the mine was tipped over by a passing vessel, the cover fell off and pulled the serrated wire through the friction fuse, which fired the black powder and exploded the mine. These mines were made in two sizes, one for fifty pounds of powder and one for one hundred pounds. They were moored under water by means of anchors, and with the mine described below, Fig. 4, represented the most advanced form of contact mine used by the Confederates.

The mine shown in Fig. 4 was made of boiler plate, conical underneath and spherical on top, and was filled with black powder. Equally spaced around its greatest horizontal circumference were four sensitive plunger fuses (a,a,a). When the mine was struck, its tendency was to sheer off and revolve about its vertical axis, and this brought one of the plunger fuses in contact with the ship's side and caused the explosion. It is interesting to note that up to the time of the destruction of the *Commodore Jones* in 1864, only mechanical contact mines were used with any success. The *Commodore Jones* was, however, distroyed by an electric mine such as is shown in Fig. 5. This mine was also one of the first observation mines. The means of locating the vessel for firing was afforded by two stakes arranged in front of the firing point so that a vessel passing up the channel would be over a mine in prolongation of the line of the stakes at the moment the mine was fired.

The Confederate electric mine, Fig. 5, was cylindrical in shape with conical ends. It was filled with black powder, and into the center of the charge two electric wires (a) were led through the base plug (b). These wires were joined by a platinum bridge (c) and imbedded in a small primary charge (d). When the current was sent through the wires, the platinum bridge was heated and the primary charge and mine fired thereby.

In the Franco-Prussian War 1870-71 the superiority of the French over the Germans in the matter of ships, was greatly

neutralized by the latter in their use of electrical, mechanical, and dummy mines for harbor defense. Although nothing of importance in the development of submarine mines is to be found in this conflict, the moral effect of the planted German mines was sufficient always to keep the French fleet at a respectful distance.

In the Russo-Turkish War, 1877, only one case of destruction by mines is found, that of the Turkish gunboat *Suna*,

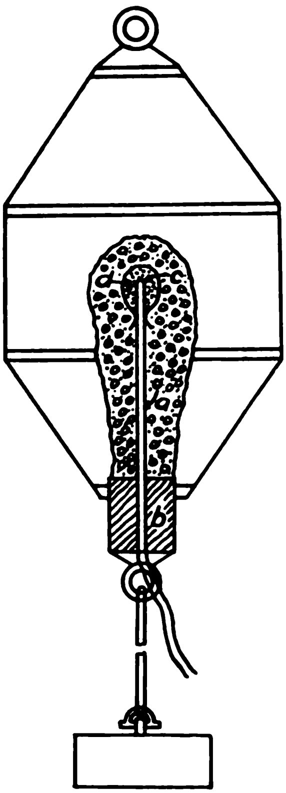


Fig. 5. 1483

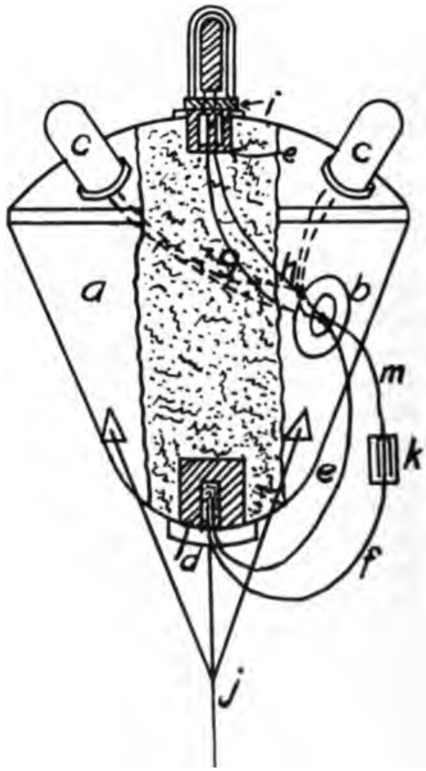


Fig. 6. 1484

which ran into a Russian electric contact mine in the harbor of Salina and was sunk.

The Russian electric and mechanical mine used in the Russo-Turkish War, 1877, is shown in Fig. 6, in which (a) is the conical shaped mine case, (b) the filling hole, and (c,c,c) horns, of which there are five, set into the head of the case. The horns are composed of a glass tube containing a chlorate of potash

mixture enclosed in a lead tube, over which is screwed a brass safety cylinder. When ready for action this brass cylinder is removed. Directly beneath each of the tubes and inside the case is a thin brass cylinder (e) closed by a piece of wood (i). This cylinder contains several pieces of zinc and carbon arranged in the form of a battery, the zinc and carbon wires (g) and (h) being led through the piece of wood (i). The copper cylinder (d) contains a primary charge of guncotton and a detonating fuse. The terminals of the fuse are connected to two insulated wires (e) and (f); the former of which is led to the filling hole (b) and connected on the inside to five zinc wires (g). Each zinc wire (g) is attached to one end of a safety arrangement (k), the other end of which is connected to five carbon wires (h) by means of the wire (m). The safety arrangement contains a spring by means of which the current can be made or broken within the case (k). When the mine is planted, the brass tubes (c) are removed, leaving the lead tubes exposed, and a connection is made in the safety device (k). When the mine is struck and any one of the lead tubes is crushed, the chlorate of potash mixture falls onto the zinc and carbon pieces, thus making a battery, which produces a current and explodes the mine. To convert the mine into an electric contact one, the wires (m) and (f) were connected to others leading to the shore. By substituting for the horns (c,c,c), solid brass plugs, the mine could be converted into an observation mine. In this case, the two wires (e) and (f) would have to be connected to a battery at the observation station on shore.

In our own service soon after the Civil War, attention became directed towards submarine mines as a method of defense. The development of a system employing mines was placed in the hands of the Engineer Department in 1869, under the direction of General Henry L. Abbot, with headquarters at the Engineer School at Willets Point. General Abbot conducted numerous experiments covering the construction, operation, and planting of mines.

In 1886 the completed system called for two different kinds of electrical mines, ground and buoyant. The ground mine was so arranged that it could be exploded by use of an attached buoy in which a circuit was closed when the buoy came in contact with a passing ship. The buoyant mine was the one for general use. It was of steel and spherical in shape. In appearance it was the same as our present service 32-inch case. Its compound-plug, while similar to the one in use to-day, was

more apt to get out of order, due to the delicate adjustment of its circuit-regulator. Its circuit-closer consisted of a ball and cup arrangement which operated on the same principle as the present one. The loading-wire, after entering the mine at the bottom of the compound plug, led to the chamber containing the primary charge, corresponding to the present fuse can, where two fuses were put in the circuit; from the primary-charge chamber the wire led to the circuit-regulator where it divided, one lead going to the circuit-closer and the other going through the circuit-regulator. When the mine was tipped sufficiently, the ball and cup joint made the signal circuit, and short circuited the high resistance coil of the circuit-regulator, which was normally in the line for testing purposes. This short circuiting of the high resistance coil greatly increased the current in the cable, and operated the signal in the casemate. This current was insufficient to fire the fuses, and not until the high voltage firing battery was thrown in was it strong enough to explode the fuses and the mine. If it was desired to fire the mine by observation, the firing battery was attached in the reverse direction and, by a magnet arrangement in the circuit-regulator, the high resistance coil was short circuited and sufficient current passed through to fire the fuses. Without the firing battery in circuit, these mines were harmless. By putting in the firing battery, however, the mine could be either used as a contact mine or fired by observation.

To offset the effects of displacement by strong tides, in harbors where such conditions existed, the elongated type of case similar to the present one was designed. In some locations even the greater buoyant force of these elongated cases was insufficient to keep the mine in its true position.

The mines were placed in grand groups of twenty-one mines each. The single conductor of each mine led to a triple junction-box one hundred feet in rear of the line of mines. Here the three cables were united in a cut-out-box which was inside of the junction-box, into a fourth single-conductor cable which extended back to the grand junction-box, situated a short distance in rear of the center of the group. In the grand junction-box each of the seven single-conductors was connected to one of the cores of a seven-conductor cable running back to the casemate. This arrangement of circuits allowed for firing any one mine *by contact;* but, if *judgment*, or *observation*, firing was attempted, all three mines of a group of three must be fired. The normal method of firing was by contact,

the tracking of vessels at that time not having been developed to its present stage. In planting, the triple junction boxes were placed in line three hundred feet apart and the mines themselves, one hundred feet apart. The mines were loaded with dynamite No. 1, this explosive having been adopted after a long series of experiments in which the following qualifications were considered: greatest intensity of action when fired under water; retention of strength, both in storage and when loaded in mines; convenience in handling; and market facilities. The primary charge consisted of a small amount of guncotton in which the fuses were placed.

The above system was that used by our Engineer troops during the Spanish War.

The mine service was under the direction of the Corps of Engineers till Feburary, 1901, when the mine matériel was transferred to the Artillery, by which branch of the service all subsequent operations have been carried on. The Artillery has entirely changed the operation of the system.

In the foregoing history of the submarine mine, only the salient points have been noted. For the benefit of those who desire a more complete record of mine development, an outline covering the more prominent operations and events in the history of the mine from 1585 to the present, follows.

OUTLINE OF THE LEADING EVENTS IN THE DEVELOPMENT OF THE SUBMARINE MINE

1585—Lambelli's attack on bridge at Antwerp. Vessels, each carrying a heavily charged magazine fired by clockwork, were carried by stream against the bridge, which was completely destroyed.

1775—Bushnell's numerous small experiments with gunpowder, by which he proved that a charge of powder could be fired under water.

1777—Bushnell's attack on the English man-of-war *Cerebus*, off New London, by floating torpedoes.
Bushnell's attack on English ships at Philadelphia with floating torpedoes. Known as "The Battle of Kegs."

1797—Robert Fulton's experiments with torpedoes on the Seine. These attempts were generally failures.

1801—Fulton's attempt to sink a small vessel in France by means of his torpedoes. This was completely successful; the first case of a vessel destroyed by a torpedo.

Charge of the submarine mine, twenty pounds of powder.

Fulton's unsuccessful attempt to destroy one of the English channel fleet with drifting torpedoes.

1804—Fulton's expedition to destroy the French fleet at Boulogne. Failed due to a mistake in the construction of the torpedoes.

1805—Fulton's destruction of the brig *Dorothea* off Dover with drifting torpedoes.

1810—Fulton's attempt in New York to destroy the U. S. sloop *Argus* in final test of the efficacy of his torpedoes. Failed, owing to torpedo nets being put out by the ship's commander. These are the first torpedo nets known to have been used.

1829—Colonel Colt's use of a submarine battery and mine to blow up a raft.

1843—Colonel Colt's successful experiment in the destruction of a vessel under way by electric submarine mines. Several mines were planted in the ship's course.

1846—Professor Schönbein's discovery of the explosive agent, guncotton (which is brought into use for military purposes about 1863).

1846—Sobrero's discovery of the explosive agent, nitroglycerin.

1854—Russian attempt to destroy the English men-of-war *Merlin* and *Firefly* at Cronstadt, by stationary submarine mines.

1862—Confederates' use of contact mines, the Federal gunboats being considerably delayed in attempting to force the Savannah River. This is the first use of the mine in a practical form during the Civil War.

1862—Confederates' destruction of the Federal gunboat, *Cairo*, by stationary torpedo. Two torpedoes exploded under her, causing her to sink at once.

1863—Confederates' successful operations against the Federal gunboat *Commodore Barney*, on the James River, severely damaging her with an electric submarine mine containing 1750 pounds of powder. The ship at the time of the explosion was steaming nine knots.

1864—Confederates' complete demolition of the *Commodore Jones* on the James River, by means of an electric torpedo charged with 1750 pounds of powder, the river having been previously dragged.

Confederates' instantaneous destruction of the Federal monitor *Tecumseh* at Mobile Bay, the ship striking a mechanical contact mine.

1867—A. B. Nobel's introduction of dynamite, a modified form of nitro-glycerin.

1869—General Abbot's beginning of the first systematic experiments to develop a suitable mine defense for our harbors, and adoption of dynamite as a loading charge.

1877—Russian destruction of the Turkish gunboat *Suna* by means of an electro-contact mine.

1886—Relief of General Abbot from further mine investigations, the matter passing into the hands of a series of boards.

1898—U. S. Engineer Corps at the beginning of the Spanish War mined most of our important harbors.

1901—U. S. Engineers transfer all mining operations to the Artillery. Congress makes appropriations for several mine planters. The School of Submarine Defense is organized at Fort Totten and the development of the present system is begun.

1904—Russian mine layer *Yenesei* strikes one of her own contact mines in Ta-Lien Bay and was sunk.

Russians lose the *Boyarin* in Ta-Lien Bay in the same manner.

Japanese mines laid in the night in path usually taken by Russian fleet cruising outside of Port Arthur.

Japanese destroy the Russian battleship *Petropavlovsk* by one of the above mentioned mines.

Russians destroy Japanese battleships *Hatsuse* and *Yashima* while they are cruising off Port Arthur. They struck contact mines dropped by Russian mine laying ship *Amur*.

Japanese try to bottle up Russian fleet in Port Arthur by dropping mines in the entrance.

Relation to the Other Elements of Defense and Tactical Employment

The object of placing a system of submarine mines for the defense of a harbor is to arrange it so that a war vessel passing along the channel must at some moment, whatever course she may take, be in such a position as to come within the destructive radius of one of the mines in the system. Since submarine mines are principally obstacles and their function is to delay,

the position of the mine fields should be such that, when the enemy is passing over them, he will be under the most destructive fire of the defense on shore. This position is always dependent on local conditions, such as depth and width of channels, and velocity of currents and tides. These conditions may force a location which is not always ideal from a tactical point of view.

The best and most destructive zone of fire for the defense is that in which the guns of the primary armament can pierce the side armor of battleships and in which the mortars can be used effectively against the deck armor. As the inner limit of the field of fire of mortars is just short of 4000 yards and the guns of the primary armament also have a destructive effect at that range, 4000 yards should mark the approximate position of the outer limit of the mine fields and the place where the hostile fleet should first be delayed.

Inside of 4000 yards mortar fire can be but little used. At these shorter ranges, however, the rapid fire guns assigned to the mine defense can be used effectively against raids, and the mine searchlights can be used with good results, in case the mine fields are attacked by parties in small boats. The most probable time for such attacks will be during foggy weather or at night; and for this reason, the mine fields should be in close enough to be protected by the rapid fire guns and illuminated by the mine lights.

The enemy will always try to destroy the outer and inner mine fields before he starts to force the entrance. As it is of great importance to him to remove them, and equally important to the defense that they be not removed, a struggle will take place at that part of the channel which they occupy. The attack on the outer mine fields will probably be carried on by torpedoboats or submarines. This attack will have to be repulsed by the rapid fire guns of the defense, as to bring the larger guns into action at this time would disclose their position. Mines alone are a passive means of defense; but, after the harbor is cleared of them, the problem of attack is much less complex and the opportunity of forcing the entrance greater. Because of this, the defense must make every endeavor to hold the mine fields and keep them intact. If, by any chance, some of the mines are removed by the enemy, they must be replaced at the earliest possible moment by the mine planter of the defense.

Considering the necessity of delaying the enemy in the most effective field of fire, and also the possibility of raids and

successful operation against them by the mine defense, the inner and outer limits of the mine fields should be respectively about 2500 and 4500 yards from the position of the guns of the primary armament.

The rapid fire guns and mine lights should be placed as far forward as possible, but not in such detached positions that they can be readily captured by raiding parties, or destroyed by the fire of the enemy's smaller guns. The mine lights should be so placed that they are masked by day, so their position cannot be definitely determined. They should be on low sites, so that their beams will not interfere with those of the larger lights used at greater ranges. They should be so placed that they have an unobstructed sweep of the mine fields and can illuminate any object in them to the best advantage of the rapid fire guns of the mine defense. The lights should be of sufficient number to illuminate all the fields at once, thus barring the possibility of raids at different points of the fields at the same time. The guns assigned to the mine defense should have a free field of fire over the planted mines and their accessories, and should be of sufficient number to repulse immediately any attack on them. This number should bear a definite proportion to the number of groups planted.

Assuming the mine system now in use in our service to be the one under discussion, the following general rules should not be neglected when locations for the fields are to be selected.

1. Always three, and if practicable more, groups should be planted in echelon across the channel, thus making it impossible for a ship to pass along the channel and attack by surprise without striking one of the mines.

2. The mines should cover a large area of the channel. The inner group should be near the inner limit, 2500 yards, and the outer near the outer limit, 4500 yards.

3. In general, the mines should be placed in channels navigable only to large vessels, the shallow channels being made impassible by passive obstructions, such as sunken ships or heavily laden scows.

4. Mines may be used in conjunction with floating or passive obstructions or alone. If used in combination with obstructions, they should be so located that their explosions cannot injure the obstructions.

5. In deep water it is more necessary to use several groups of mines than in shallow. In the latter case, a vessel sunk by a mine would in itself, offer an obstruction to other

vessels following. While in deep water an explosion of a mine leaves an opening in the line through which there is a safe passage so far as that particular group is concerned.

6. Mines should be planted in the narrowest part of the channel, thus requiring a smaller number.

7. Mining casemates should be located in those parts of the fortifications most likely to be held the longest, so that control of the mine fields can be kept until the last moment of defense.

8. Care should be taken to lay the multiple conductor cables in such positions as to render their discovery by the enemy as difficult as possible. The cable for an outer group should not pass through an inner one, but should go around its flank. Cables should not be crossed; crossing renders underrunning impossible.

9. Mines should not be exploded for small boats, but held in reserve for larger vessels.

10. The positions of the mine fields should be well covered by the guns and lights of the mine defense; also by the guns and lights of the primary armament, as the gun defense and mine defense are mutually dependent for their most effective action. If planted beyond supporting distance of the guns, mines can only be relied upon to delay. This was exemplified in the Russo-Japanese War at Ta-Lien Bay where the Russian mines did not prevent the Japanese from eventually using Dalny as a base from which to operate against Port Arthur. The bay at Ta-Lien had been thoroughly mined with contact mines by the Russians, and it took the Japanese several weeks to clear it sufficiently for free use, even after it had fallen into Japanese hands.

11. The positions of the planted groups should be known to vessels in the navy of the defense, so that the ships may operate freely without danger of fouling the mines or cables, as well as without danger of being destroyed by the mines. At the battle of Nan Shan in the Russo-Japanese War, the Japanese navy was prevented from aiding the army by the Russian mines; while the Russian ships, knowing the location of the mines, could more safely sail along the coast and render assistance to their forces on land.

12. During raids on the mine fields, the firing current of the regularly planted groups should be kept off, and none of these mines should be exploded unless it becomes apparent that its location is discovered and it is about to be rendered

non-effective. The advanced mines, however, should be exploded as soon as they are tampered with, in order to deceive the enemy as to the location of the regular groups and lessen his ardor in the search.

13. As the enemy in clearing the mine field would make a passage by sweeping, dragging, or countermining, several heavy chains could be laid across the channel in front of the outer group to foul his grappling irons and deceive him as to the true location of cables. Dummies could also be placed in front of the loaded mines, but never so that they would lead to the discovery of the planted mines. During reconnaissance by the enemy, the firing current should be kept off the regularly planted groups and the mines should not be set for contact firing. If a run-by is attempted, the groups directly in front of the attacking fleet should be set for contact firing as soon as the fleet is in its immediate vicinity. The firing current on all other groups should be kept off to prevent them from being exploded by small vessels bent on raiding.

14. The arrangement of a group of mines in a line has one serious disadvantage; *i.e.*, if an enemy has once located the position of one of the mines he can readily determine that of the others. In order to overcome this disadvantage, several mines could be scattered at irregular intervals over the area in front of the regularly planted groups. These mines could be arranged for either contact or observation firing, as circumstances required. The destruction of small boats of raiding parties by these advanced mines would have a very salutary effect on further operations of this nature.

In this paper no attempt has been made to lay down a scheme of defense contemplating the use of mines that might be applicable to any or every fortified harbor on our coasts. The foregoing principles are general and are not new, but are gathered from facts covering the tactical use of mines in the principal wars since the submarine mine has become a potent weapon. The scheme of defense for each and every harbor will have to be prepared long before an actual attack of that harbor is eontemplated. The strongest defense that a harbor can make will be that in which the attacking ships are held in the zone of the most effective fire of the primary armament. This can be brought about only by placing the mines with this end in view. In the writer's opinion, this can best be effected by the application of as many of the foregoing principles as the local conditions of the harbor permit.

OUR MILITARY AND NAVAL POLICIES IN THEIR RELATION TO OUR FOREIGN POLICIES

By Colonel STEPHEN M. FOOTE, Coast Artillery Corps

I. Historical References

Foreign policies are not determined in a day: each one is usually evolved in a step by step process extending through a considerable period. In our Republic the policy may first be enunciated in a Presidential message or other State document; or it may first be advocated in the platform of a political party, or in debate upon the floor of Congress; but sooner or later it must go to the people for their support or rejection.

Again, some of our national ambitions, some of our domestic policies, may have as decided a bearing as direct foreign policies on our relations with the rest of the world.

One of the earliest foreign policies of the United States was that of "No entangling alliances," which was intended to free us from any possibility of war, being, apparently, well suited to an infant nation struggling to establish itself in a distant quarter of the globe; but in carrying it out we were at one time brought to the verge of war with France.

But whatever the origin of a policy, and however stiff and uncompromising it be, the student of United States history will look in vain for a muster of forces preceding its exercise. On the contrary, it often happens that those advocating the most aggressive foreign policy are the very ones who refuse to provide any force to back it up.

It was war between England and France that helped our country gain its independence; and a generation later, after years of war talk without any adequate preparation, we engaged in a second war with England; and again war between England and France helped us through.

A few years later the Monroe Doctrine was announced, with no idea, apparently, that any force would be required to maintain it. The doctrine is firmly imbedded in our national creed, upon it having been erected many fantastic theories of

foreign policy; and in all its varying phases, it has more than once brought us to the verge of war.

From the War of 1812 until after the Mexican War, our relations with Great Britain were under a strain of varying intensity.

In the Presidential campaign of 1844 one of the slogans of the party whose candidate was James K. Polk, was "Fifty-four forty or fight"; the meaning of which was that the northwestern boundary line between British dominions and United States territory was to be a north and south line, United States territory extending north along the Pacific coast to the southern boundary of Russian territory on the American continent. This slogan was in the nature of an "ultimatum with a declaration of war," and when Mr. Polk became president he took vigorous measures to carry out its spirit, the only result, however, being that, whereas Great Britain had claimed the lower Columbia as the boundary, the 49th parallel was finally accepted.

While it is true that from about 1820 to the Mexican War the United States did build some excellent permanent fortifications in our principal harbors, yet in other respects no special preparations were made to support the aggressive foreign policy of the period.

An aggressive foreign policy prompted by the desire of enlarging our territory along the south to keep pace with the extension to the northwest, brought on the war with Mexico, a weak nation still further weakened by internal disorders; and after a protracted campaign we were successful, in spite of inadequate preparation and many administrative blunders.

Quite different was the case, when at the close of the Civil war, a powerful army and a small but efficient navy brought our diplomatic controversy with France concerning the Mexican situation to a speedy and satisfactory conclusion.

Later, the *Virginius* affair was closed with Spain by a small show of force; and in the Venezuelan incident, though it looked serious for a time, England apparently did not care to challenge the Monroe Doctrine, even though it was not backed up by a large army or navy.

A long period of what we were pleased to consider Spanish misrule in Cuba had wrought in the United States a spirit of protest against its continuance, when the catastrophe of the *Maine* brought our people to their feet in an indignant demand for war. But it was not in their calculations that we

had a stronger navy than Spain, or that we could set on foot inside of three months an army sufficient to defeat the Spanish army in Cuba: if we had had no stronger navy than Spain and no more than a corporal's guard on land, we should probably have demanded war just the same. Fortunately we were able, in spite of administrative blunders, to force Spain to sue for peace in a hundred days.

By reason of the war with Spain, the United States has assumed a new position in the family of nations. Instead of her activities being confined to the continental limits of her territory, she has extended into the Caribbean Sea and into the northern, central, and western Pacific.

At the same time, a new world power has arisen in the Pacific. The policy of Oriental exclusion, which, when introduced, worked smoothly, is, under changed conditions, a different matter. New questions of international interest have arisen with regard to the Panama Canal. Obligations never dreamed of by the dreamers who laid the foundations of the Monroe Doctrine are pressing upon us. And the Mexican situation since 1910, like that of Cuba in the nineties, has been growing more and more acute, and some catastrophe, like that of the *Maine*, would probably have a similar result.

II. Estimate of the Situation

Hitherto, the adoption of a policy in this country has not, as a rule, been preceded by military preparation or by a careful inventory of our available resources to carry out such policy. Such has been the acknowledged latent strength of the country in men, material, and money, that it has not been thought necessary to marshal our forces in order to show that we have them. Our self-confident method of procedure has generally succeeded almost as well as if backed up by a strong army and navy.

But inasmuch as pretentions of the United States since the Spanish War are being taken much more seriously than formerly; and inasmuch as the idea seems to be gaining ground that, as an abstract proposition, a policy likely to provoke foreign opposition must be supported by force; it would seem that the time has come when we should undertake some scientific, logical process for determining the steps necessary to carry out the desired policy.

The President and his cabinet, with the personnel of the various departments, constitute the executive branch of the

Government, upon whom must fall the execution of any policy determined by the people, either by the initiative or referendum. If a policy, on further consideration, appears impracticable or for other reason undesirable, the people will signify its recall.

In the solution of such a problem there may result an estimate of the situation in something like the following form.

ESTIMATE OF THE SITUATION

Mission.—Owing to the changing nature of our Government from one administration to another and from one party to another, our policies are peculiarly exposed to change. But it is surprising with what tenacity certain policies are held. The Monroe Doctrine, for instance, is held with as great tenacity by one political party as by another.

The mission must be formulated after a general study of the trend of events in relation to the subject and a determination of the course it is desirable to follow.

And just here let us hope that our policies may be progressive, in keeping with a more liberal and enlightened view of international duties than is generally credited to other nations or than is generally contemplated by ourselves.

In the first place, our treaty obligations must be scrupulously observed. If a treaty is antiquated, or for other reason no longer desirable, steps should be taken to change it, not break it.

In the second place, due regard should be paid to the rights of others. This is a simple statement of a plain moral duty. But think of its conscientious application and it will be realized how little consideration is given it in the dealings of nations with each other.

In the third place, consideration must always be given to the moral and political obligations which we, as a great and powerful nation, owe to our weak neighbors.

In general, the mission should be formulated, or at least approved, by the Cabinet.

Having, then, a statement of the mission in approved form we may now take up the opposing forces.

Opposing Forces.—What they are or are likely to be; what nations may oppose the policy, why, how and to what extent—from moral, political, commercial, and military standpoints, including in each case a statement of the temper of the people; state of preparedness for offensive operations, including financial and material resources; state of coast defenses, size of army

and navy, and time required to mobilize; amount and character of merchant marine adaptable to military purposes; other matters bearing on the subject from the point of view of each possible enemy, courses of action open to the enemy.

Our Own Forces.—A statement of the attitude of our people towards the policy; our state of preparation to defend the policy, including financial and material resources, state of coast defenses, size of existing army and navy and time required to mobilize same; size of army and navy considered necessary and time required for accomplishing the increases, if any; other matters bearing on the subject with relation to each possible enemy; courses of action open to us with reference to each possible enemy.

We shall now be in a position to strike a balance and see what may be needed in money, material, time, and men to enforce the policy. We may then weigh the chances of success or failure and judge whether the policy should be enforced, postponed or abandoned. If it is decided to carry out the policy we also have in this estimate the information on which to base our plan of action.

Decision.—The decision, embracing a plan of action, may now be recommended to Congress, or informally to certain committees of Congress, by the President. The decision will doubtless be modified when Congress is heard from, so that the *Final Decision* cannot be reached until passed upon by both the Executive and Legislative branches.

III. Council of National Defense

In our government the President is the only person directly charged by the Constitution to "give to the Congress information of the state of the Union, and recommend to their consideration such measures as he shall judge necessary and expedient."

The President usually comes into the office more or less bound by the declaration of faith contained in the platform upon which he was elected. He is assisted by a cabinet composed of members of his political party.

The Secretary of State has immediate control of foreign affairs, and is usually selected from among the most prominent men of the President's party. He may, or may not, be a statesman versed in national and international affairs, well qualified by experience and attainments to hold the high office. But,

whether qualified for the position or not, he is usually a man whose ideas have great weight with the people.

The Secretary of the Treasury is usually an experienced business man; the Attorney General a prominent lawyer; and so on. But the Secretary of War and Secretary of the Navy are as a rule, when they come into office, without any knowledge of the technical features of those departments.

So that the cabinet, while prepared to handle national and international matters from a legal, political, and economic standpoint, is not versed in the military requirements that may be necessary or advisable for the support of any desired policy.

In many governments the members of the cabinet or ministry are also members of the legislative branch and are always on hand to present and explain in person any measures that have been determined by the ministry to be advisable. In our government, while such a course is not followed, cabinet officers and their subordinates are often invited to appear before Congressional committees to explain various features in measures that are up for consideration.

In order to bring the executive departments of the government interested in our foreign policy and the allied subject of national defense into closer relations with each other and with the committees of Congress having charge of those matters, a bill was introduced in the House in 1911 to bring together a board of officials to be called a "Council of National Defense." This bill was reported with amendments, but was never put upon its passage. In April, 1913, the bill, as amended, was reintroduced in the House and was referred to the Committee on Naval Affairs.

The purpose of the council is to "report to the President, for transmission to Congress, a general policy of national defense and such recommendation of measures relating thereto as it shall deem necessary and expedient."

The membership is to be as follows:

1. The President of the United States (ex-officio president of the Council).
2. The Secretary of State.
3. The Secretary of War.
4. The Secretary of the Navy.
5. The Chairman of the Senate Committee on Appropriations.
6. The Chairman of the Senate Committee on Foreign Affairs.

7. The Chairman of the Senate Committee on Military Affairs.
8. The Chairman of the Senate Committee on Naval Affairs.
9. The Chairman of the House Committee on Appropriations.
10. The Chairman of the House Committee on Foreign Affairs.
11. The Chairman of the House Committee on Military Affairs.
12. The Chairman of the House Committee on Naval Affairs.
13. The Chief of Staff of the Army.
14. An officer of the Navy not below the rank of captain, to be selected by the Secterary of the Navy.
15. The President of the Army War College.
16. The President of the Naval War College.

The bill provides that the council shall meet at least once a year, except in time of war, when it shall meet only upon the call of the President; grants it power to call persons before it for consultation; and appropriates money to pay its expenses.

Such a body will be continuous. To be sure, the President and the cabinet officers are subject to change at one time, but the Congressional members and the Army and Navy members do not necessarily change with them. The probability is that not more than eight of the sixteen members would be changed in any one year.

It would seem that a council so composed should be able to study and decide upon definite policies from a theoretical standpoint and decide upon the preparations necessary to enforce them from a practical standpoint. If the council decides that a certain policy is wise, just, and advisable, it can at once proceed to a consideration of what defense, if any, it may need from possible encroachments by other nations with whose activities it may interfere. Theory and practice will thus be coordinated. The authoritative recommendations of the council, consistent and comprehensive as they will doubtless be, should have great weight with Congress and with the nation.

IV. Joint Board

Desirable as such a council would seem to be, it is uncertain as to when, if ever, it will be created. In the meantime, the question of proper national defense is awaiting solution;

and, assuming that a council is created, when it meets, a scheme of national defense should be ready for presentation.

Who should prepare such a scheme? Naturally, the Army and the Navy.

How shall it be prepared?

Each branch has been working for many years, independently, on special features of preparation for a defensive war—the Army through its service schools, service journals, War College, and General Staff; the Navy through its Naval Institute, War College, and General Board.

As might be expected, whenever the two services must come together in any way, the plans fail to connect, overlap, or otherwise conflict. To rectify such differences the War and Navy Departments, by mutual arrangement and without any special authority of law, appointed a Joint Board a few years ago and have continued it to the present time. The board consists of four Army and four Navy members, its present* membership being as follows:

ARMY

Major General Wood, Chief of Staff.

Major General Wotherspoon, Assistant Chief of Staff. (Formerly President of the Army War College.)

Brigadier General Crozier, Chief of Ordnance.

Brigadier General Weaver, Chief of Artillery.

NAVY

Admiral Dewey, President, President of the General Board.

Rear Admiral Vreeland, Member of General Board (until recently Aid for Operations).

Rear Admiral Fiske, Aid for Operations.

Captain Knapp, Recorder, Member of General Board. (Officer whom Captain Knapp succeeded was Aid for Personnel.)

As will be noted, this board is composed of officers who have regular work of an exacting nature and can be expected to devote only brief attention to questions suitable for consideration by the board, whether initiated by the board or referred to it. In other words, any detailed plans or projects must be prepared by others and submitted to the board for discussion and decision.

The President of the General Board of the Navy and the President of the Naval War College have immediate charge of

* February, 1914.

groups of officers whose duties are in part to perform precisely such work as is required. Similarly with the Chief of Staff of the Army and the President of the Army War College. Therefore it would seem that if these officers are members of the Joint Board they could have necessary detailed work done by their subordinates, so that all they would have to do would be to look over and modify or approve the plans before submitting them to the board.

There are certain other bureau officers whose bureaus are directly concerned to such an extent in any military or naval policy that they should be represented on the board. The following is, therefore, suggested as a proper personnel for the board, which should, preferably, be designated by Executive Orders:

ARMY

Chief of the General Staff.
Chief Quartermaster.
Chief of Ordnance.
Chief of Coast Artillery.
President of the Army War College.

NAVY

President of the General Board.
Aid for Operations.
Aid for Personnel.
Aid for Matériel.
President of the Naval War College.

Secretary: An officer of the Army or Navy, to be selected by the President of the Joint Board.

In matters concerning which the State Department would be involved, it might be arranged to have a representative of that Department attend the conferences or perhaps present the views of the Department in writing. Arrangements might possibly be made to consult with the chairmen of Congressional committees on matters that would eventually come before them.

The Joint Board could thus perform in part the functions proposed for the Council of National Defense. It could formulate plans for consideration by the council, or by the cabinet, in case the council is not created.

The bill for the creation of the council has the support of

the War Department and, it is understood, of the Navy Department. But it is believed that the work indicated for the Joint Board should be undertaken at once, regardless of what may be done about the council.

In our endeavors to coordinate diplomatic, legislative, and military efforts, *the first and most important step is to coordinate the Army and the Navy*, the two branches of our military power. In effectually accomplishing this object, much will be done towards coming to an understanding with the other executive departments and with Congress.

It is a part of the business of both the Army and the Navy to give to Congress and to the people generally the benefit of their expert knowledge. They will undoubtedly do this to much better purpose if they understand each other and agree upon the part each is to take in war and in preparations for war.

Probably the majority of officers of the Army and the Navy do not agree as to the proper functions and relations of the two services. In many cases there will be points of difference as to whether certain functions or duties belong more advantageously to one or to the other. It is better to settle these differences according to reason in time of peace than to leave them to haphazard settlement and mischief-breeding in time of war.

Our military policy has always been to have a small standing Army in time of peace; but the corollary, *a practicable scheme for rapidly raising an adequate Army in time of war* has never received serious consideration.

One self-evident truth, that our Navy cannot be much expanded in time of war, and its corollary, that *the Navy must be maintained at war strength in peace as well as in war*, seem to be pretty well grasped by Congress and the people. The vital question is what is an *adequate* Navy?

Questions like these would seem suitable for consideration by the board.

It is believed that the Joint Board, as an active, working body, can, without any additional legislation, do much towards clearing up doubtful questions concerning military and naval policies in their relation to our foreign policies—and thus assist the President, the Cabinet, and the Congress in deciding upon what measures of military preparation are necessary in carrying out any desired policy.

ARMOR AND ITS APPLICATION TO SHIPS: HISTORICAL

By 1st Lieut. ROBERT ARTHUR, Coast Artillery Corps

While the idea of protecting ships of war by means of armor plate is not of so recent conception as may be generally supposed, its practical application, like that of many inventive designs, was delayed until long after the first trial; and armored ships, as we know them, date from about the middle of the nineteenth century. Prior to the sixteenth century, the wooden sides of the ships were depended upon for protection against hostile missiles, and, with the advent of guns and their increase in power, the thickness of the sides of the vessels increased. The *Great Michael* which was built by James the Fourth of Scotland, who was killed at Flodden in 1513, was 240 feet in length and 56 feet in breadth, but, as the sides of the ship were 10 feet in thickness, the interior breadth was only 36 feet. While this great thickness was given to the sides of the vessel for the purpose of protection, it scarcely entitles the *Great Michael* to be classified as an armored vessel, and the first of these does not appear until 1530. One of the largest ships of that time, belonging to the fleet of the Knights of St. John, was covered entirely with lead and was said to be successful in keeping out all the shot of the period. The practice of using lead armor does not, however, seem to have become general.

The question of the application of armor to ships of war for the purpose of protection from an enemy's fire, caused but little concern until the beginning of the nineteenth century, although the French had designed floating batteries in 1782 with a novel means of protection. These vessels, which the French employed in their attack upon Gibraltar, were covered with junk, rawhide, and timber to the thickness of 7 feet, and had bombproofing over the decks. Unfortunately for the French, this armor-plating was combustible and the ships were easily set on fire with red-hot shot. Still the French seemed to like the idea of floating batteries, for similar vessels were again used some seventy years later by them in the Crimea.

The earliest recorded proposal to employ iron armor for

war vessels seems to have been made in England by Sir William Congreve in 1805. In 1812 John Stevens, of New Jersey, designed a ship with a battery protected by inclined armor. In 1814, a bomb-proof vessel was patented by Thomas Gregg of Pennsylvania. The Stevens family continued to work on the subject of iron armor and had, by 1841, determined by actual experiment, the penetrative powers of the projectiles of the day against wrought iron. In 1842 R. L. Stevens began the construction of an iron-armored ship which was never completed. In 1845 M. Dupuy de Lome designed an armored frigate.

In 1814 the first war steamer ever built, the *Fulton*, was launched and demonstrated the possibilities of steam in the construction of navies. This ship was designed by Robert Fulton and called by him the *Demologos*. She was essentially a floating battery, the precursor of the *Monitor*, with two 100-pounder guns on pivot mountings and with a ram-shaped bow. She was driven by a steam paddle in the center of the ship, and was armored with wood so thick that it was proof against the shot of the time. The *Demologos*, upon being launched, became known as the *Fulton the First* and was considered the *Dreadnought* of the day. She attained a speed of 3½ knots, but was not completed in time to demonstrate her possibilities in the war.

By 1822 shell guns had been adopted and the question of protection to ships became more important than it had been before. General Paixham, the inventor of the shell gun (*canon obusier*), himself suggested that the only reply to shell was armor. The necessity for armor becoming more and more apparent, experiments were begun about 1827 in England, France, and the United States, with a view to the determination of the resisting powers of iron and its possibility of use for protection of ships.

Iron, for structural purposes, was developed rapidly, but in ship construction wood continued to be used almost to the exclusion of iron, until the middle of the century; and even in 1850 there were constructors who declared that iron was unsuitable for ships. With the introduction of steam, however, ships increased rapidly in size and wood became unsuitable, because of the greater stresses to which the larger ships were subjected. The local strength and stiffness of a wooden ship was great, but the structural strength was considerably less than that of the iron vessel. Iron was, therefore, practically forced upon ship designers.

It is of record that an iron boat, intended apparently for passenger service, was built and launched on the River Foss in Yorkshire in 1777, and during all the latter part of the century iron was, according to report, used in the construction of canal boats and barges. The first iron steam boat in the United States, of which there is definite record, was the *Aaron Manby*, built in 1820. The U. S. S. *Wolverine* (ex-*Michigan*) built in 1842, was the first iron warship in our service, and is still in use (out of commission) on the Great Lakes.

The use of metal in the construction of merchant and passenger vessels developed much more rapidly than in naval construction, because of the slower increase in size of naval vessels. However, by about the middle of the nineteenth century iron had been definitely adopted and the navies of the world were continuing with ships of metal that struggle for supremacy which had begun with ships of wood.

In 1840 the British Admiralty conducted experiments to test the action of shot against iron plates backed by various substances, and it was concluded that iron was a poor material for ships of war.

In 1842 armor experiments were conducted with iron plates made by riveting together plates three-eighths of an inch in thickness to a total thickness of six inches. These plates did not successfully resist 8-inch guns or heavy 32-pounders at 400 yards; so some modifications were introduced and further experiments made in 1850. This laminated armor was never reported on favorably; and general opinion, at about this time, was somewhat against armor. The French, however, formed a more favorable opinion of iron armor than did the other nations, and, in 1853, they constructed five floating batteries which carried four inches of iron armor.

These ships were almost totally unmanageable because of their bad lines, and their speed never exceeded four knots. They were of light draft and carried eighteen 50-pounder guns with a crew of 320. It was intended that they should be able to use either sail or steam; but, when it was discovered that they refused absolutely to proceed under sail, the masts were removed and pole masts substituted. Notwithstanding their many defects, three of them were sent to the Crimea, and it is reported that it was necessary to provide transports to carry their guns for them. Having arrived safely, they joined a large fleet in the attack on Kinburn on October 17, 1855, and, by steaming in close to the fortifications, the floating batteries

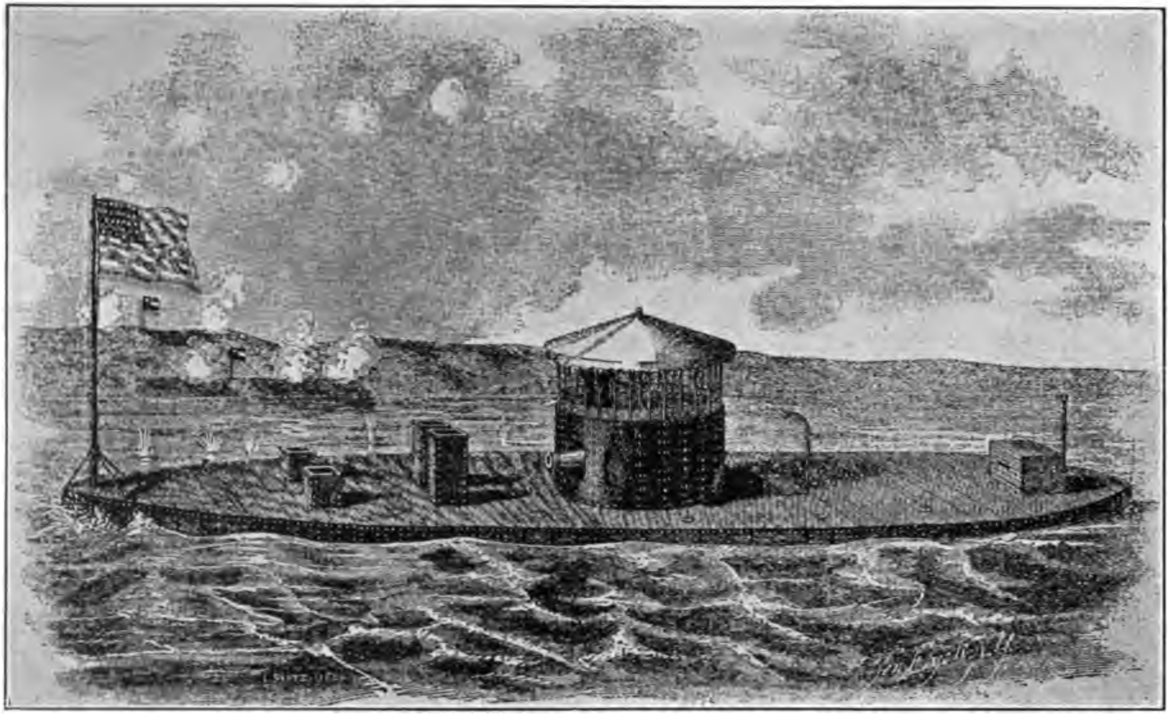
were ennabled to silence the batteries in the course of a four-hour engagement without material injury to themselves.

It was no doubt the success of the floating batteries in this attack which led the French to adopt armor plating for their ships of war; and so it is the French who are to be credited with having produced the first sea-going iron-clad, *La Gloire*, and, with her, that contest between gun and armor which has not yet ended; for improved kinds of guns and armor are still being sought and experimented with.

La Gloire, together with the *Normandie*, the *Invincible*, and the *Couronne*, were laid down in 1858; but scarcely were their frames up before England replied by laying down the *Warrior*, the *Black Prince*, the *Defence*, and the *Resistance*. By 1862 all the naval powers of the world had taken notice of the new naval developments. Italy had begun the *Formidable* in 1860; Russia, the *Petropalovski* in 1861; and the United States, the *New Ironsides*, the *Galena*, and the *Monitor* in 1861. At this same time Spain, Austria, Denmark, and the Confederate States also had iron-clad ships either afloat or under construction.

While the European ships were, for the most part, modifications of existing types, the American ships were constructed from new designs, or railway iron and the like was attached to existing vessels. The *Monitor* was a distinct novelty, not only because it was built entirely of iron, but also because it was the first of the turret ships. The battle between the *Monitor* and the *Virginia* (ex-*Merrimac*), being the first encounter between armored vessels, may be said to have opened the modern armor-clad epoch, for it demonstrated definitely that the wooden war vessel already belonged to the past and that armor was a factor which would have to be considered in all naval designs of the future.

The credit of introducing the monitor type of vessel comes to the United States only because the presence of the *Virginia* in the Confederate Navy made necessary the rapid design and construction of the *Monitor*. While Ericsson was designing this vessel, Captain Cowper-Coles was designing the *Rolfe Krake* for Denmark. Coles proposed a turret ship which was to carry seven or nine center-line turrets, each containing two guns which were to recoil up a slope and return automatically to position. It is improbable that either Ericsson or Coles used the other's ideas, as has been charged, for neither invented the idea of turrets. Turret-ships seem to have been proposed



Scientific American. 1151

ERICSSON'S MONITOR OF 1862.

This engraving, first published in the *Scientific American* of March 22, 1862, was drawn by the *Scientific American* artist at the Brooklyn navy yard, just before the "Monitor" sailed for Hampton Roads. Naval authorities consider it one of the most accurate representations ever published.

in the sixteenth century, and pivot guns had long been used. Ericsson's turret revolved on a spindle; while that of Coles revolved on a series of rollers and was, therefore, more practical.

The advance in gun construction began at practically the same time as the advance in ship and armor construction. A wire-wound gun was proposed in the United States in 1850 by Dr. Woodbridge and in England by Mr. Longridge, C. E.; in the same year, 1855, Mr. Mallett, in England, advocated a built-up cannon. While the manufacture of armor plates progressed rapidly from the first, the improvements in gun powder forced a continually increasing thickness of the plates.

While soft iron had been adopted for the armor for ships, experiments continued with this and with laminated armor, hard iron, and, later, chilled iron, steel, and the plate-upon-plate system. In 1861 various backings such as timber, cork, india-rubber, layers of wire, etc., were tried and it was concluded that, "while the hard materials improved the resisting power of the armor, they led to its being more injured by cracking, and to the giving way of fastenings." At about this same time, a Special Committee on Iron (British) came to the following conclusions:

"1. That steel and steely iron are bad materials for armor, while soft iron is best.

"2. That corrugations and bosses, designed to break shot on impact, are undesirable.

"3. That plates should be large as practicable.

"4. That hard backing supported the plates at the expense of the bolts, whose functions are not only to hold the plates on but also to resist vibration and prevent buckling.

"5. That tonguing and grooving of plates tend to spread injury from plate to plate, and are bad.

"6. That the effect of shot on plates is not proportional to the momentum of the former, but to the energy, * *."

The advantages of a hard pointed projectile with which to attack the soft armor soon became apparent, and Sir William Palliser introduced an ogival-pointed chilled-iron shot. His projectiles were first tried at Shoeburyness in the autumn of 1863.

In 1864 steel plates made their first appearance, plates supplied by the Thames Company, Brown & Co., the Parkgate Company, and Petin & Gaudet, being unsuccessfully tested in Russia in this year.

With the adoption of armor protection for ships of war, all the principal nations of the world, with the exception of the United States, began the construction of armor-clad navies with a feverish activity, which continued until the eighties. Up to 1875 the contest between gun and armor had wrought iron armor on one side and cast iron projectiles on the other. There had been no material improvement in the manufacture of projectiles since the introduction of rifled cannon other than that (noted above) caused by chilling the ogive in casting. Neither had there been any essential improvement in the manufacture of armor-plate; so the steadily increasing power and caliber of the gun had forced a continually increasing thickness of armor-plates. The climax was reached in 1876 when the *Inflexible*, a ship of 11,880 tons, was given 24 inches of armor amidships. In this ship an outer thickness of 12-inch armor-plate was backed with 11 inches of teak, behind which was another 12-inch armor-plate backed with 6 inches of teak. Inside all this were two thicknesses of 1-inch iron plating.

As the weight of armor to be carried by ships could not be increased indefinitely, an improved kind of armor with which the gun might be successfully opposed became necessary. The Italians seem to have been the first to recognize this, for they began a series of experiments at Spezia in 1876 upon several forms of target, with their attention especially directed to steel. The steel employed tended to shatter upon impact of the projectile; but it was noted that projectiles which passed completely through wrought iron plates were stopped by the steel plates. As a result, the Italians fitted the *Dandolo* and the *Duilio* with armor belts consisting of 21.65 inches of solid steel. These were the first ships to carry steel armor.

These experiments gave added stimulus to the investigation of steel for armor; and, from this date, experiments were conducted under the conviction that wrought iron would be replaced sooner or later by steel in some form. Mr. George Wilson, of the Cammel Company, patented a compound armor in 1876 which was to compete with the all steel armor. This armor consisted of a steel face welded to a wrought iron back and offered the advantages of a hard surface and a tough body. Experiments in 1877 with plates consisting of 5 inches of steel united to 4 inches of wrought iron showed this compound armor to be superior to wrought iron plates, and further experiments showed that best results with compound armor were obtained when the steel constituted about one-third of the plate.

Naturally, a contest between the all-steel and the compound armor resulted, and the compound armor seemed at first to have the advantage; but, with the introduction of the steel shell a little later, the advantage turned to the steel plate. The compound plate was produced mainly in England and the steel plate mainly in France, and rivalry between these plates continued until the Annapolis and Ochta experiments of 1890. At these trials the superiority of the steel plate was demonstrated beyond a doubt; but both plates were found to be inferior to a new nickel-steel plate which had just appeared.

The introduction of the compound and the steel armor gave the plate the advantage over the gun, and investigations were conducted with a view to the determination of the best material for projectiles. One series of experiments was conducted by the British Admiralty in 1877 with chilled iron projectiles of various kinds, steel projectiles, and projectiles with steel bodies and chilled iron heads. Among other things, they recommended:

"That all battering projectiles should have heads struck with a radius of 2 diameters.

"That the question of a delay-action fuse to be used with guncotton be further investigated.

"That a certain proportion of forged steel shells be issued.

"That cast steel shells be not adopted unless greatly improved."

In this same test was tried a wrought iron cap on the point of the projectile. This was brought about by the fact that it had been discovered that a steel faced armor plate lost its power of breaking up chilled shot when a 2½-inch wrought iron plate was placed over the face of steel plate. Captain English and General Inglis thought a cap would serve the same purpose as the iron plate. The effect of the first shot encouraged further investigation, but further trial showed that "no advantage was gained by a cap."

Other experiments were carried on by all the manufacturers of projectiles. Krupp, Hadfield, Holtzer, Armstrong, Firth, and others tested cast steel, forged steel, specially treated steel, and steel alloys, until the Holtzer works advanced a chrome-steel projectile which was successful against the new armor. With a chrome-steel projectile, Holtzer in France and Hadfield in England became most prominent as projectile manufacturers.

The projectile having again gained the ascendency, it

became necessary to effect the destruction of the chrome-steel projectile; so the plate manufacturers began to increase the hardness of the face of the plates. Captain Tressider, R. E., patented a method of face hardening in 1887, which was first applied to the compound armor. In 1889 Schneider introduced nickel into steel; and in 1891 or 1892 the St. Chamond works used nickel steel with a small percentage of chromium.

The armor which was adopted for replacing the steel and the compound armor was a face-hardened nickel-steel armor introduced by Mr. H. A. Harvey, of the Harvey Steel Works of Newark, N. J. This is the armor mentioned above as having been tested at the Annapolis trials. These trials led to further tests at Indian Head, and the results were so successful that Harveyized nickel steel armor-plate was adopted for warships.

The United States Navy, at this time, was in its infancy, so far as modern navies were concerned. Little interest had been taken in the development of the Navy after the close of the Civil War. As though satisfied with the production of the first monitor, this country allowed the Navy to decay for twenty years, with the result that, in 1880, there was not a really seaworthy seagoing warship belonging to the Navy, while practically all the ships owned were sailing vessels. All other countries had definitely discarded sailing war vessels long before this; so, as a naval power, the United States stood near the foot of the list. In 1880 the country appeared to awaken to its naval needs and interest in naval development was soon apparent.

Our modern navy then dates from the early eighties, that is, from about the time of the development of steel in naval construction. Our first ships, the *Dolphin*, the *Boston*, the *Atlanta*, and the *Chicago*, laid down in 1883, were given steel hulls. From this time on the United States continued to lay down ships and to strengthen the Navy, until, in the early nineties, it began to be recognized as a naval power. The *Monterey* (1891) and the *Indiana* class (1893) were the first ships to carry Harvey armor. The Spanish-American War brought the Navy not only to the attention of the world, but, what is more important, to the attention of the American people; and since then the United States has forged rapidly to the front as a naval power.

In 1893 Krupp introduced a face-hardened armor, nickel chrome steel with special heat treatment, which soon super-

seded the Harvey armor. This armor, known as Krupp Cemented (K. C.), was adopted by Germany on the *Kaiser Wilhelm II* in 1897. By 1901 this new armor had been adopted by all the naval powers, and now practically all the principal armor of all the navies of the world is Krupp Cemented.

In regard to recent improvements in armor very little has been made public. Several new kinds of armor or methods of manufacture have recently been reported, and it may be that K. C. armor will soon be discarded, as have all preceding kinds.

The Schaumann plate, recently invented, consists of a light steel plate backed by a plate of duralumin. The two are welded together at various points, but not solidly. The new plate is lighter than steel and it is stated that the inventor expects to equal the best Krupp plate with 25 to 30 per cent less weight.

Another new plate is the Simpson, which consists of a hard tool steel plate and a tough steel plate welded together, with a sheet of copper between, giving a weld which is practically invisible, the welded plates being molecularly continuous.

Hadfield has produced a cast steel plate which has been very successfully tested, and the use of these plates seems to be becoming more and more general.

However, the quality of armor in general use has not greatly improved since 1897, while, on the other hand, guns have enormously improved at the same time that there has been improvement in the projectile itself, as well as that due to the adoption of the cap shortly after the Russian trials in 1894. With the introduction of the 13.5 and the 14-inch guns in the last year or so it may be said that the gun has again attained superiority over the armor; so, according to all precedent, we should see a new or improved armor adopted in the course of the next few years.

In this continuing struggle between the gun and the armor there have been many changes and modifications in the construction of the ships themselves. The change to steel permitted a lighter construction, giving a decrease in the dead weight and an increase in the allowable weight for armor and armament. Improvements in the methods of manufacture since that date have permitted of many improvements in the details of construction.

In types of ships there has been a great change. The old wooden sailing ship carried a battery arranged for broadside fire, while the battleship of today is prepared for heavy end-on as well as broadside fire. The intermediate armament came

into being on armored ships and passed away, battleships of to-day carrying only big guns and some torpedo defense guns. The old line-of-battle ships were high sided and from this type we jumped to the monitor with practically no freeboard. The battleships and battle-cruisers of today have worked back to the high freeboard and its elevated gun platform, which permits the use of the guns in a seaway and gives greater stability to the ship.

In size also there has been a marked increase since the beginning of the modern era. Warships increased very gradually but continuously in size from the 1400 tons of the French floating batteries to the 12,000 tons of the pre-Dreadnoughts. Since then they have increased very rapidly to the 30,000 tons of to-day, with 40,000 tons proposed, with the result that battleships launched ten years ago have to-day but little value. As the Panama Canal can accommodate battleships up to 43,000 tons only, that would seem to be the present limit in size, at least for the United States.

The *Dreadnought*, which marked the beginning of the rapid increase in size of warships, is about the only epoch-making development in naval science originating in Great Britain, but it opened a new era in ship design for the navies of the world. This ship was based on the design of "the ideal ship for the British Navy," published in 1903 by Colonel Cuniberti, Constructor to the Italian Navy. The ship, whose design had been declined by the Italian Navy because it was too ambitious for that power, was to be of 17,000 tons displacement and was to combine in itself the offensive and defensive powers of two or three battleships. The idea was not taken seriously, until, in the Russo-Japanese War, it was announced that the battleships *Aki* and *Satsuma*, which had been laid down, were to be more or less on the lines of Colonel Cuniberti's design. At the same time it was announced that the United States had started the *South Carolina* and the *Michigan*, each carrying four two-gun center-line turrets.

Both of these ideas were public property before the *Dreadnought* was laid down, but she was built with such rapidity that she was completed before any other vessel of the type, and her building was shrouded in so much mystery that she received considerably more advertising than did the other vessels. Japan and the United States are obviously entitled to a great share of the credit for originating the Dreadnought movement. The *South Carolina* type, all big guns on the center

. all bearing on either side, was a distinct novelty. No ·ecy whatever was observed about them and the United tes is probably the first nation that definitely adopted the ·big-gun idea.

The Dreadnought idea spread rapidly, each nation striv-g to out-do the others by increasing the size and armament each vessel laid down. This has resulted in a type known the super-Dreadnought which surpasses the *Dreadnought* as uch as that vessel surpassed its immediate predecessors.

The development of the vessels in the United States Navy nay be traced by taking ships from the time of the *Texas* to the atest types:

Ship Class	Date	Length Feet	Breadth ft. in.	Mean Draft ft. in.	Displacement tons	Belt ins.	Large Turrets ins.
Texas	1889–95	301	64 1	22 6	6,237	12–6	12 N.S.
Indiana	1891–96	358	69 4	24 —	10,288	18–15	17 H.
Iowa	1893–97	360	72 2	23 11	11,410	14–11	14 H.
Kearsarge	1896–00	368	72 2	23 11	11,525	16–14	15 H.N.
Alabama	1896–00	368	72 2	23 9	11,552	16–14	14 H.N.
Maine	1899–02	388	72 3	23 9	12,500	11–7	12 H.N.
New Jersey	1902–06	435	76 2	23 9	14,948	11–8	12 H.N.
Louisiana	1903–06	450	76 10	24 6	16,000	11–9	10 N.S.
Kansas	1904–07	450	76 10	24 6	16,000	9	12 K.
Idaho	1904–08	375	77 —	24 8	13,000	9–7	12 Mid.
South Carolina	1906–09	450	80 3	24 6	16,000	11–9	12 N.C.
Delaware	1907-09	510	85 3	27 —	20,000	11–10	12 N.C.
Utah	1909–12	510	88 2	27 —	21,825	11–10	12 N.C.
Arkansas	1910–12	550	93 2	27 —	26,000	11	12 Mid.
Texas*	1911–13	565	95 2	27 —	28,367	12	14 Mid.
Nevada	1912–14	575	95 3	28 6	27,500	14	14
Pennsylvania	1913–15	600	97 0	28 10	31,400	16	—

Thus it is seen that the battleship, from its earliest days, has been increasing in size and in its offensive and defensive powers, until today we have colossal 30,000-ton super-Dreadnoughts which were undreamed of fifteen years ago. What the future holds in store in the line of naval development only the future can tell. There is at present a vague feeling among the younger element in the Navy that the days of the battleship are numbered, and that further development will be along other lines. This idea has appeared on previous occasions, but its present advocates point to the recent developments in the submarine, in the torpedo, and in aerial navigation. It remains to be seen, however, whether the battleship will retain dominion over the sea or whether it is doomed to disappear, future wars being decided in the air or beneath the surface of the waters.

* See the frontispiece.

its make-up should be carefully studied by each battery commander. To illustrate this, take the case of a three-inch rapid fire battery, 1903 carriage, for the target practice year of 1914. From page 40, *Regulations for the Instruction and Target Practice of Coast Artillery, 1914*, we read as follows:

128. *Figure of merit for guns, battery practice.*—For the purpose of determining the comparative excellence of companies in battery service practice, each company will be given a figure of merit to be computed by the battery commander and reported on Form 819, as follows:

For 3-inch, 4-inch, and 4.7-inch guns—

$$M=\frac{8\times C\times H^2}{Pgtn \sin B}$$

* * * * * * *

In the above formulas for the figure of merit—
M=the figure of merit.
C=constant for particular mount and caliber. (See par. 129.)
H=the total number of hits for the series.
P=probability of hitting, taken from tables for mean corrected range.
g=number of guns used in practice.
t=corrected time of firing series in minutes (to third decimal place).
n=number of shots fired.

* * * * * * *

B=mean angle in degrees of track of target with line of shot.

* * * * * * *

On page 41 of the above mentioned regulations, we find that C =3.2 for 3-inch guns, a factor which cannot be changed in any way; and on page 32 we find that for rapid fire guns the inferior range shall not be less than 1500 yards and the superior range not greater than 4000 yards. Table III, page 43, states that P is unity up to 2000 yards, after which it decreases to 0.5 at 4000 yards. Par. 89, page 31, states that the coast defense commander will cause the target to be towed as nearly as practicable on a course which shall make an angle of not more than 70 degrees nor less than 40 degrees with a line joining the battery and the tug. From the above it will be seen that the battery commander has no control of the range, which determines the probability factor, or of the angle at which the tug tows the target.

In addition to C, P, and B, there are two other factors which may be considered constant and which the battery commander must accept as he finds them. These are n and g. The number of shots to be fired is 40 for each practice, as per par. 50, page 19, and the number of guns used will be two.

We may therefore conclude that the variable factors with which the battery commander must deal are H and t; but, before passing to the consideration of these, attention should be invited to par. 95, page 32: "Upon receiving assignment of

a target the battery commander will at once fire a string of five shots, when he will cease firing and report to the fire or mine commander for a new assignment of target." That paragraph together with the above mentioned constant factors, therefore, carries the requirement that the battery commander shall be ready to fire *instantly* at any range between 1500 and 4000 yards, and at a target towed on a course between 40 and 70 degrees from the line joining the battery and the tug.

Having concluded that the battery commander has left only H and t with which to work out as large a figure of merit as possible, let us see the importance of each. In the first place, the value of H is emphasized by the fact that it is squared and multiplied by 8. So, while it goes without saying that, the greater t, the less will be the figure of merit; yet the importance of t is insignificant as compared with H.

In the study of how to obtain the largest possible figure of merit, we should go further than the analysis outlined above. That is merely the preliminary outline of a study that should be made before starting drill for target practice. In addition, the *Regulations for the Instruction and Target Practice of Coast Artillery Troops* should be scanned daily, in order that the battery commander may be able to take advantage of every opportunity offered for increasing his figure of merit. A table which will show the relative importance of H and t should be compiled, assuming mid and extreme conditions of ranges. The table on page 43 may serve to show the various figures of merit to be expected during this season.

The all-surpassing importance of obtaining hits will be readily seen from the table.

The table may serve to furnish the figure of merit for any number of hits, and corresponding time, by proper interpolation. It is to be expected that 3 minutes for the 40 shots will be improved upon, and the figure of merit increased accordingly. Too much importance, however, should not be attached to shooting rapidly. But it is important that the battery commander fire immediately upon assignment of target, as the time counts therefrom, as per par. 63, page 25. If he is sure his first shot is through the center of the bottom of the target, no time need be lost in getting off the remaining shots of that part of the series. But if he is not sure, sufficient time should be taken to make proper corrections.

Possibly it may be thought that too much stress is being placed upon attaining a high figure of merit; but let us recall

2500 Yards and 60 Degrees

No. of hits.	M for 3 min.	M for 5 min.	M for 8 min.
1	.037	.02	.012
2	.148	.08	.048
3	.333	.18	.108
4	.592	.32	.192
5	.925	.50	.298
6	1.332	.72	.432
7	1.815	.98	.587
8	2.369	1.28	.767
9	3.00	1.62	.971
10	3.70	2.00	1.200
11	4.45	2.42	1.452
12	5.46	2.88	1.729
13	6.43	3.38	2.150
14	7.44	3.91	2.350
15	8.33	4.51	2.710
16	9.46	5.11	3.034
17	10.7	5.76	3.456
18	12.0	6.44	3.864
19	13.4	7.22	4.332
20	14.8	8.00	4.800
21	16.3	8.82	5.292
22	17.9	9.68	5.808
23	19.6	10.56	6.348
24	21.3	11.51	6.901
25	23.2	12.51	7.271
26	25.0	13.51	8.101
27	27.7	14.58	8.488
28	29.0	15.69	9.409
29	31.1	16.8	10.08
30	33.3	18.0	10.8
31	35.3	19.2	11.5
32	37.9	20.2	12.3
33	40.3	21.8	13.1
34	42.7	23.1	13.9
35	45.3	24.5	14.7
36	48.0	25.9	15.6
37	50.6	27.4	16.5
38	53.5	28.9	17.4
39	56.4	30.2	18.3
40	59.2	32.0	19.2

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ned officer or a man who has had much service, is no rea-
hy he should occupy any special position at a rapid fire
ry. The battery commander should take the place of each
at the battery at different times and actually *feel* the
onious work of every man before he attempts to obtain
lity. A rapid-fire battery, above all others, must have
work; so not the slightest detail to make men work
ther should be overlooked. It is too often thought that
pid fire battery doesn't amount to much, is easily operated,
doesn't need much attention. This is a wrong idea and
uld be corrected at the very beginning. Such a degree of
actness should be required that it will only remain for the
ttery commander to eliminate errors of ways and means.
you, as a battery commander, can attain this, half of your
ork is over and you are well along toward a good figure of
nerit.

From this time on, do away with each little rub of friction between members of the gun crews, until all work harmoniously together. To accomplish this you must try out many men for the different positions at the piece; so you can make a tabulated list of the men who can fill the various positions, arranged in the order of excellence of work. This is very important, because men are always leaving your command for various reasons, and you must know who is the next best for every position at any time.

As many subdivisions as possible should be made among the gun and fire-control sections. Let us again take as our example a battery of two 3-inch guns, model 1903 carriage, and a vertical-base position-finding system. Let the observer and reader work together, and instruct them to work slowly and accurately. Have the plotter work slowly and accurately with the arm setter, and let him give you corrected ranges from ranges and azimuths which you give him. After both the observing and plotting detachments have each shown that they can work accurately, let them work together. After the fire-control section has been tested in every conceivable way for accuracy, start the time interval bell and let the men gradually become accustomed to working with it. Explain the necessity for exactness and attach no criminality to failure to get a correct range. Encourage missing a range rather than getting a wrong one.

In the meantime, have telephone operators talk to each other, repeating orders and ranges which are most apt to be

used. Have the range-setter and gun-pointer work together. First teach the pointer continuity of aim by making him keep his vertical wire on the center of the target for short periods of time. Then give the range-setter change of range exactly as you expect to do on the day you fire. At first give him only exact range settings. During these changes of range have the pointer keep his vertical wire on the center of the target always. Having found that the pointer is not confused by having his ranges changed, instruct him in setting his deflection scale. Then work with these two men, changing range and deflection until you are sure they have attained a great degree of accuracy. Finally, teach the pointer to take deflection at all ranges. Watch the range-setter throughout all drill and keep him alert. Impress upon him the importance of correct range settings. He can cause a zero score more easily than any other man. Now have No. 1 operate the breechblock as in simulated firing, first slowly and then more rapidly. Have the pointer pull the firing bar every time the breech is closed after No. 1 calls "ready." Watch the pointer carefully; you may determine at this very point whether or not he is gun-shy. If he is, drop him right here, and select another pointer. A man who is gun-shy may fill any other position, but he will never do to fire the gun.

During all this time when the pointer and range-setter become tired, have Nos. 1, 2, and 3 work together. Of this group No. 2 is most important. His steady loading will do more to assist the pointer to get his shots off rapidly than the work of any other man. No. 1 should operate the breechblock with as little jar as possible and always in the same steady manner. No. 3 merely gets rid of the empty cartridge cases as they are thrown out, but he must be taught to keep clear of Nos. 1 and 2 always. With dummy ammunition these men can work together at first slowly and then more rapidly, until No. 2 has attained uniformity of loading and great speed.

It now becomes necessary to decide upon a method of bringing up the ammunition from the recess or loading table. Each man in the ammunition detail should be taught how to hold each round and just how to place it in the arms of No. 2; and, having delivered it, how to return to the ammunition recess or loading table without getting in the way of any member of the gun and ammunition detail. This is not as simple as it first appears, and must be mastered before rapidity can be attempted.

A method of analyzing the figure of merit was first described. The above may be considered as an analysis of the personnel of the battery. To lay down specific rules for analyzing human nature is impossible and it is therefore not possible to lay down more definite rules for analyzing any gun detachment. But let it be understood that the greatest element in successful shooting with a rapid fire battery is this analysis of the gun and range-finding detachments, and the more the battery commander knows about the reliability of his men the more consistently will his battery shoot well.

During the above mentioned period of elementary instruction and training, it is also necessary for the battery commander to ascertain the general condition of all his equipment. He may find a lack of spare parts for the guns, badly corroded subcaliber tubes, weak subcaliber extractor springs, poor sight buffers, poor means of obtaining ranges, etc., etc. It is for him to correct everything possible and place his battery on a war footing. If he does not look after every detail as early as possible and take steps to improve conditions which he has found, he cannot expect to get any help, and, after he has completed his target practice, he may not even get the sympathy he expects.

We now come to the third step in the preparation for target practice. Having analyzed our figure of merit and learned that we must hit the target with a fair degree of rapidity, and having analyzed our men and instilled as much as possible of exactness into them, we are ready to train for rapidity of action.

The ammunition detail and gun crew can now be assembled and slow gun drill attempted. Careful attention must be given to the elimination of interference between the groups heretofore instructed, and for this reason work should start slowly and speed be gradually attained, never at the expense of steady, accurate work. Do not introduce any time element into the drill until all interference is eliminated. When all gun detachments have arrived at that stage at which they are doing good, steady, consistent work, have the range section furnish ranges; have them transmitted to the range setters; and have all guns take up the drill together. After all interference has again been eliminated, each gun detachment should be timed, and now for the first time speed attempted.

At this point greater stress than ever must be laid on accuracy in every detail. The pointer must follow the center

of the target constantly and continuously. He must not be permitted to get ahead of the center and then wait for the target: he must always be on, so that he can fire the instant No. 1 calls "ready." The range setter must follow the ranges carefully. They are always either increasing or decreasing. He must therefore never jump past a range and then come back to it. Cool, steady work on his part will mean much to the officer who is observing and controlling the fire. No. 1 must operate his breechblock in the same steady manner, and No. 2 must load just as carefully as at first.

Above all things, work for accuracy on your first practice. The men can then see the result of their work in percentage of hits, even if the figure of merit is not so large. It is, by far, easier to develop speed after accuracy has been attained than to get accuracy after speed has been developed. This is particularly true due to the fact that we have only poor means of ascertaining the accuracy and truthfulness of each member of the detachment. But, even if we had better means, it would still be more difficult to break the men of bad habits acquired during rapid drill than to start them right by slow accurate work.

So far, three distinct operations in the preparations for target practice have been described. Every detail in the training of the battery has been seen to devolve upon the battery commander, but no mention has been made of the training to which he should subject himself. There is no phase of coast artillery work which depends so much upon the work of one man as does the target practice of rapid fire batteries upon the battery commander.

He must give his orders so that they will be heard without question. If he cannot do so without a megaphone, he should use one which will transmit his orders distinctly above the noise of firing. He should give as few orders as possible and should use only short distinct orders which are easily distinguished from one another. All such unnecessary orders as, "With target practice ammunition, commence firing," should be eliminated. No member of the gun detachment needs to be told what ammunition to use after it has been laid out before him. It is quite sufficient to say, "Commence firing."

As stated above, much depends on the battery commander. But that is no reason why he should do all the work himself. He should delegate to his subordinates every thing possible. If he does the spotting, he should have one man work a range

board to make the additions and subtractions as corrections are made by him, and another to work a deflection board to make additions and subtractions for the deflection. The exact range and deflection can then always be transmitted to the range-setter and pointer. The battery commander need then only use the words "up," "down," "right," "left." For instance, "Up 100" would mean for the operator of the range board to increase his range 100 yards. "Left 2" would mean for the operator of the deflection board to move the deflection two points further left.

The spotter should control the deflection of all guns, as well as the range. Pointers have all they can do to keep their deflection properly set, keep the vertical wire on the center of the target and fire the piece as rapidly as it is loaded. To make them correct their deflection gives them more than they can do, even when each fires singly. When they fire together, it is impossible for them to distinguish their own shots, and confusion will arise which will make it impossible for the spotter to control his fire in any way. Even if the battery commander acts as spotter, he can do no good watching the work of his gun detachments in action. He must leave this to his gun commanders. He will therefore have vastly more time to make corrections, even if the guns fail to fire together, than will the pointers. Should the guns not fire together, a very improbable occurrence if corrections have been properly applied to range and deflection scales, there is only one thing to do and that is to give separate corrections to each gun.

The question of spotting is an important one and one which is a study in itself. No man can tell you how he does it. But this much is known: a good spotter must have unlimited practice and training; he must never hesitate; he must give his corrections automatically and must have the courage of his convictions to give what comes to his mind at the instant that the shot strikes the water.

The battery commander must live for target practice only. He should let nothing interfere, make him excitable, or in any way get on his nerves. Whoever does the spotting should build a spotting board with a miniature target, and, with the aid of some one to place the shots, practice with his glasses, so that he can move the shots right up to the target without hesitation. A table with a dark green cloth over it will answer. Upon this can be placed a miniature target whose size is proportionate to the size of the rapid fire target,

as is the distance between the small target and the spotter to that between the battery and the rapid fire target. The battery commander must go through his own training during the time he is training his battery: by the time the battery is ready for subcaliber practice he also should be ready.

Having attained a fair degree of rapidity combined with all the accuracy possible, the battery is ready for subcaliber practice. This can in no way help Nos. 1, 2, and 3 of the gun detachment or any member of the ammunition detachment. But it is of great value to the spotter in carrying on his instruction. It is also of considerable help to the gun-pointers, if not continued too long; and it is a means of testing the accuracy of the pointers and reliability of the range-setters. Wrong ranges and wrong deflections should often be given to see if the pointers and range-setters have any tendency to make corrections themselves; such corrections should never be tolerated. If preliminary instruction has been good and the right men selected for pointers and range-setters, shots will fall together at the range and deflection given.

During subcaliber practice all means of communication are tested under firing conditions, and a fair idea of the work of the range section can be formed. If error or friction of any kind should be found, it should be eliminated before proceeding further, for at this stage of the game we are fast approaching real target practice and there is no time to lose. Subcaliber practice may be conducted again and again, but, after each practice, drill should be taken up in order that the loading and ammunition detachments may not become rusty and lose that rapidity and steadiness which has already been acquired.

Drill and subcaliber practice should not be continued too long. Never should it drag along to that stage at which the men lose interest. Should it appear that the work is becoming too monotonous, vary it by cleaning and overhauling the guns and by making preliminary preparations for target practice. Overhaul breechblocks and see that they work as freely as possible. Thoroughly clean the bore of each gun and carefully examine the screw box for burs, etc. Overhaul friction bands. Take all lost motion out of both training and elevating gearing. Thoroughly clean recoil cylinders. All of these are things which must be done thoroughly before target practice and to which attention can be given in advance of the practice to relieve the monotony of the drill.

As the time for target practice approaches, the observing

instruments and plotting board must be carefully checked; guns must be bore-sighted, sight errors eliminated, and range drums checked. Ammunition must be selected, projectiles cleaned, and cartridge cases carefully examined for irregularities. Rotating bands should be calipered and care taken that as nearly uniform ammunition as is possible to obtain is selected for each practice. Nothing should be overlooked in the preparation of a rapid fire battery for target practice which would be attended to in the preparation of a great gun battery for practice. Just because everything is smaller, is no reason why it should be neglected: it is all the more reason why every precaution should be taken. Still, this is where most battery commanders fail. Many do not consider a small battery of sufficient importance to waste time on it; or, it is concluded that hits cannot be made with small guns, and, therefore, there is no use trying to do anything.

When the day of target practice has finally come, the battery commander should allow no one to annoy him. He should take his time. He will most probably find something which he did not expect would arise. Under no circumstances should he report ready to fire until he is ready in every detail.

Just before the practice, guns should be checked very accurately by clinometer. Each inch of the tide should be considered and temperature of powder considered and recorded. The fact that guns shoot further as they heat up is often lost sight of when first firing, and too often are muzzle velocities taken which represent ranges with cold guns. To allow for this heating of guns during action, to insure getting shots short rather than over, and thereby increasing the probability of hitting by ricochet hits, and to assist the spotter, actual ranges should be so corrected as to place the center of impact at the water-line of the target and never should it be more than one-third the height of the target above the water-line.

In only a few mintues after the practice begins all is over, and the figure of merit demonstrates conclusively how well the weeks of drill and training have been spent. As soon as it is concluded, the range drums should be carefully examined, and the range and deflection read at each gun. Each man should be questioned concerning his own individual work, whether there was any interference; whether there were mistakes made; whether the guns functioned properly, etc., etc. If there were errors, they must be truly ascertained and corrected before the next practice. Mistakes can be eliminated only by con-

stant drill, and particular attention should be given to those points at which weakness was displayed. Tabulate everything, so that a study may be made of the practice without having to rely on memory for details.

Having completed the first practice successfully with a large percentage of hits, the drill should only be maintained to hold the accuracy acquired and to increase the rapidity by a small amount. If the percentage of hits was small, find out what was wrong and start all over as if you had never had a practice. In the latter case, it is still not too late to make excellent scores at the succeeding practice. If this practice has been the means of showing up errors, it may also be the means of giving to the battery a large figure of merit for the following practice. To eliminate errors is the reason for insisting upon truthfulness, exactness, carefulness, and accuracy in every detail. Battery commanders who can gradually eliminate errors and constantly increase in accuracy and rapidity of shooting, or who having arrived at an average degree of efficiency in gun fire can maintain it, win out in the end by consistent shooting and are sure to stand at or very near the top.

From observation of work on board ship, it appears that greater efficiency could be obtained if the following were provided and used in connection with the training for rapid fire target practice: loading machines, check gun-sights, flexible speaking tubes, and telescopic bore sights.

Loading machines are now less used than formerly by the Navy, due to the fact that there is less reason for rapidity of loading during salvo firing. But, if we are to continue even a fairly rapid rate of fire, we must use a means of working up to it, without battering the screw-box and injuring the breech-block during drill. Our allowance of spare parts is so small that drill is often dispensed with to save parts which must be used at target practice. The loading machine is the means by which the greatest speed in loading can be attained without injury to the gun.

The check sight is merely a sight which can be used by the pointer and the battery commander at the same time. It consists of two eyepieces placed at right angles to each other, both provided with buffers. The rays of light for the pointer come through just as at present, but the image formed for the battery commander is reflected at right angles. With such a telescope, the battery commander can watch the aiming of every shot

and know exactly where the pointer has his vertical wire every time he fires. This is more necessary than the loading machine, due to the fact that rapidity of loading can be obtained at the expense of gun construction, whereas the battery commander has no other way of knowing the exact point of aim during drill.

Flexible metallic hose for speaking tubes should be provided, and caps with ear connections allowed, so that all range-setters can be connected up with the telephone operator and spotter. It would then not be necessary to communicate ranges through the open air, and the range-setters would only hear ranges and their corrections.

The telescopic bore sight, while not absolutely essential to the persistent battery commander, would still be a very desirable addition for quickly and accurately checking the sights. Much doubt always arises with the crude means of checking with strings.

The importance of rapid fire batteries cannot be overestimated. The most formidable and best means of defense at the entrance of our harbors are our mine fields. We cannot afford to allow them to be injured in any way; and to prevent this our rapid fire batteries must be maintained at a high degree of efficiency.

THE GRAPHICAL SOLUTION OF PROBLEMS IN EXTERIOR BALLISTICS*

BY LIEUT.-COLONEL WILMOT E. ELLIS, COAST ARTILLERY CORPS

The following study relates especially to mortar fire, although the principles deduced are applicable in great part to gun fire.

The basic assumption underlying my discussion is that that part of the deviation of a projectile from its predicted point of fall, not chargeable to drift, change in muzzle velocity, or changes in the mean density of the atmósphere, is due to a resultant sweeping effect of the manifold and diverse air currents the projectile has encountered in its flight. A corollary to this assumption is that, if the resultant sweeping force remained constant while two shots were fired under identically the same conditions, except that one were fired directly against or with the resultant, and the other were fired at right angles to it, the range effect in the one case and the deflection effect in the other would be the same.

The projectile in its passage upwards through different layers of the atmopshere encounters winds moving at various velocities and in different directions (although generally the winds of the upper atmosphere move in the same direction, the velocity increasing with the altitude), and in its descent it passes through other and different vicissitudes. Moreover, during flight, the layer or local winds impinge in every conceivable way and complexity upon all parts of the projectile's surface. The "sweep" is the most fickle and subtle foe that the coast artilleryman has to contend with. It varies with the direction of fire, the height of trajectory, and the time of day; but in such a way as to elude forever all attempts to express its vagaries in a mathematical formula. The sweep has a most telling effect on mortar fire on account of the high angle of elevation. Due partly to our hitherto unpractical way

* In the preparation of this paper, the writer received valuable assistance from Captain John S. Johnston, C. A. C., and First Lieutenant R. E. Guthrie, C. A. C. In fact, the scheme to correct for the "sweep" by shifting the mortar arm center, originated entirely—as far as the writer's knowledge goes—with Captain Johnston.

of dealing with sweep, and partly to its elusive nature and greater effect in mortar fire, the accuracy of mortar fire has not kept pace with that of gun fire.

We cannot express the sweep in miles per hour as we measure a wind, for the former is an effect on a particular projectile measured in yards of deviation.

Although I am not at present in the position to prove my basic assumption as to sweep, I believe that it will be admitted that it is as reasonable a hypothesis as any that pretends to predict the longitudinal and lateral deviations of a projectile

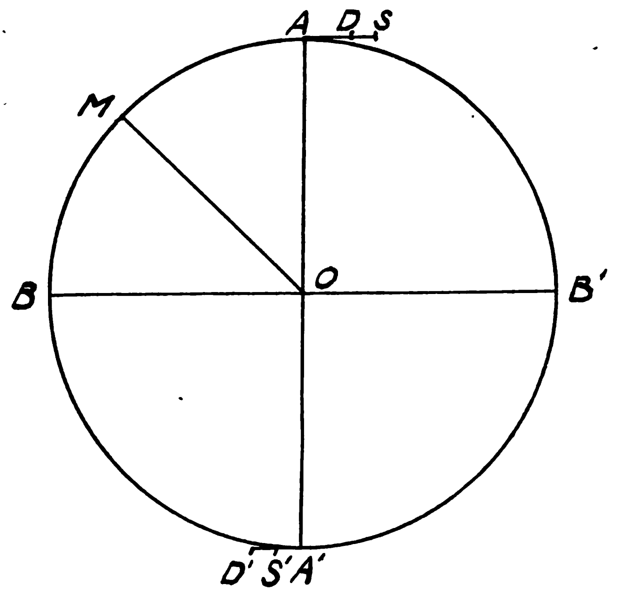

Fig. 1

Not to scale. Deflections exaggerated

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based upon surface wind conditions. In view of the simplification of the ballistic problem resulting from the theory of sweep, it is believed that it is worth testing by experimental firing. The method of making the test will be outlined later on.

Since for "wind" and "wind effect" are to be substituted in our discussion the simple term "sweep," it may be well to define it, now that we have introduced it. Sweep, then, is the deviation of a projectile resulting from the atmospheric disturbances it has been subjected to during its flight.

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The difference between tabular drift and the experimental drift thus obtained is compensated for by setting the difference off in the proper direction on the deflection scale of the deflection board.

Some of our officers have advocated firing half of the trial shots in the direction of the wind, and the other half in a direction perpendicular thereto. I do not believe that this is sound practice, for three reasons: first, there is no relation whatever between the direction and velocity of the surface wind and the sweep; second, conformity to surface wind conditions as to direction is as likely as not to throw us beyond the practical field of fire in one direction or the other; third, we should not forego the advantage that accrues from locating our target points symmetrically with respect to the direction of the mid-course point. If time presses, we may reduce the corrections obtained at the points A and B to those corresponding to the point M alone, and we cannot go far wrong in applying these corrections for the whole string of salvos, if they are fired reasonably near M.

If it be impracticable to fire at 180° target points, the trial shots should be equally divided between points A and B, so selected that the angles AOM and MOB are as near 45° as conditions permit. In the subsequent discussion, it is assumed that these angles are 45°. The necessary modifications in making the graphical analysis, when the angles are less than 45°, will be obvious.

Fig. 2 is drawn to scale, preferably on cross section paper. The radius AO should be long enough to include the maximum longitudinal deviation expected, with a hundred yards or so to spare. A, M, B, and O are the same as in Fig. 1. ON is the normal line of the plotting board. The mortar is laid on the target points A and B, using an elevation of 59°, and applying for each shot the deflection board drift correction. Lay off from A the mean longitudinal deviation AF, and the mean lateral deflection FS, S being the center of impact. Project FS on OP. Proceed similarly for the target point B, obtaining OL. Complete the rectangle OPKL. OK is the sweep, the direction being from O to K. If, now, the mortar arm center be shifted to the point K, corrections for the sweep will be automatically made, as the arm rotates about the point K. (This proposition can be demonstrated by a geometrical construction, which it is not considered necessary to insert here.) The longitudinal and lateral settings of the mortar

arm center are the two components of OK—OR and RK. Extreme care should be exercised in shifting the mortar arm center, for a mistake in setting might endanger the tug or other shipping. A check against a dangerous mistake, however, could be provided by placing stops at suitable points on the correction slides. An alternative method of correcting for sweep will be explained later on.

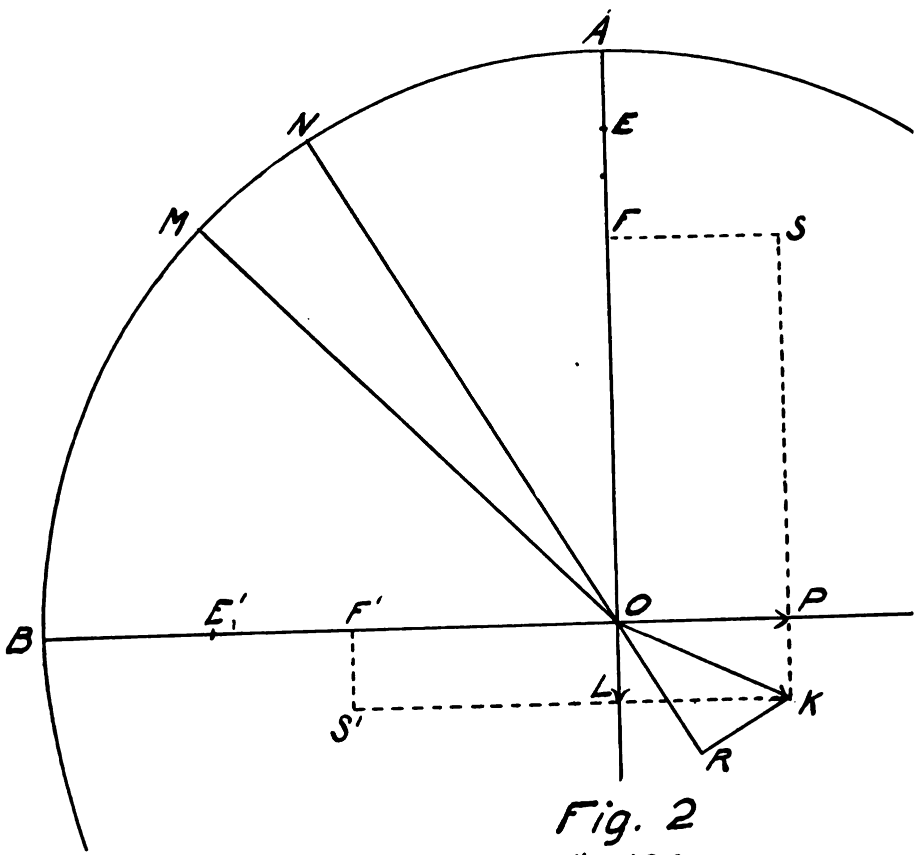

Fig. 2
Scale 1" = 100 yards

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Lay off AE equal to OL, and BE′ equal to OP. Then EF and E′F′ are the decrements of the range due to the combined effects of changes in the muzzle velocity and changes in the mean density of the atmosphere. There is no possible way of separating these two effects at target practice. Let Δ_x be the mean of EF and E′F′. Slide the zone scale in or out a distance equal to Δ_x—in our problem, in.

The method of testing the theory of sweep is now obvious. A series of shots should be fired alternately in the direction OK and in a direction normal thereto. To make the test a fair and conclusive one, the shots should be fired as rapidly as possible and on a day when meteorological conditions are fairly steady. In the direction OK, the mean longitudinal deviation minus Δ_x should be equal to the lateral deflection in the direction normal to OK, both being equal to the distance OK.

In lieu of shifting the mortar arm center to correct for sweep, we proceed as follows. Select points conveniently spaced throughout the field of fire, every ten degrees or so. The mid-course point and the terminal points of the course will usually suffice. As an illustration, let us make the corrections for mid-course. Determine the components of OK with respect to OM by a construction the same as we used for ON. Shift the zone scale in a distance equal to the longitudinal component plus Δ_x. Lay off opposite the 59° point on the plotting board a distance equal to the lateral component of OK, giving a point S″. The difference in azimuth between the points M and S″ is an arbitrary correction to be applied to the deflection scale of the deflection board.

If record practice is to be conducted in an adjoining zone, fire trial shots in the same direction as before, using, as customary, an elevation of 59°. Determine graphically the corrections to be applied. If the new OK does not differ materially in direction and value from the old OK, a mean value and direction may be used for both zones. The same is true for mean values of Δ_x. It may be parenthetically remarked that a comparison of the values of Δ_x obtained in the two zones, gives us a line on the "percentage" corrections for such zones. If mean values for the two zones are not used, the range officer should personally supervise the shift to the new zone scale correction and to the new deflection correction, both made as the target enters the new zone.

Let us now briefly discuss the application of the graphical method to gun fire. Heretofore we have fired all our trial shots in one direction only, and of course have not obtained the sweep, or the necessary data therefor. By making deflection corrections based on surface wind data, and range corrections based on surface wind data and surface atmospheric density, we have not only resorted to complex refinements, but we have actually introduced inaccuracies. The

range error may be thus expressed: $\Delta_r = \Delta_v + \Delta_d + \Delta_s$, in which Δ_r is the total range increment, Δ_v the increment due to change in velocity, Δ_d the increment due to change in the density of the atmosphere, and Δ_s the increment due to sweep. When we applied the wrong value of Δ_s (which we certainly did, when we applied the surface wind correction), we threw the unknown discrepancy on to velocity, when the discrepancy was a function of the direction of fire, and Δ_v was not. There is absolutely no use in making a preliminary correction for Δ_d, for we know nothing about the density of the atmosphere except at the firing point (or wherever we happen to install our meteorological instruments).

These considerations suggest the following procedure: Select the two target points as in mortar fire. Discard all atmosphere and wind tables. Lay the gun with deflection corrected only for drift, and range corrected only for probable velocity. Then proceed as in mortar fire to determine the value of Δ_x (equal to $\Delta_v + \Delta_d$). Make a velocity correction for the *known* sum of the *unknown* constituents, $\Delta_v + \Delta_d$.

Corrections for sweep throughout the field of fire should be made in the same way as for mortar fire, thus dispensing with wind corrections on the gun deflection board and rendering the wind component indicator useless.

RANGE CORRECTIONS FOR MORTARS

By Captain JAY P. HOPKINS, Coast Artillery Corps

The following method of making corrections from trial shots in mortar fire will eliminate all corrections or computations during practice and will provide proper corrections at all elevations for the powder used.

Plot the range and velocity for at least each five degrees of elevation and for fifty-nine degrees elevation for all zones from the range table, corrected for height of site where necessary.

Scales: 1 inch = 25 foot-seconds velocity.
1 inch = 300 yards range.

Any other convenient scale may be used for velocities. Draw curves for each elevation plotted. Note that each curve must pass through the origin and that the curves collectively give a check on the accuracy of each.

From the result of any group of trial shots, locate on the curve of the elevation used (probably 59°) the mean range of the splashes.

A range strip across the curves at this point will be the proper zone scale for use on the plotting board. It should be completed and applied to the mortar arm so that the elevation used for the trial shots will coincide with the mean range to the splashes. This process applies to all zones in which trial shots are fired.

Fair curves of times of flight should be drawn on the plot to facilitate completion of the zone scales in this respect.

A more complete plot, showing all elevations now given on zone scales, might be prepared once for all, prints thereof being made as necessary.

Instead of applying the zone scale to the mortar arm, the plot could be used as an elevation board. The time of flight could be given to the plotter, and on his announcing the range to the set-forward point, the elevation could be taken from the board. This would require several range rulers, each to be set at its proper velocity.

Having determined the range variation at any elevation in any zone, Artillery Bulletin No. 99, Serial No. 111, prescribes how to determine the range to be expected with the same elevation in other zones, and the respective points at which zone scales are to be taken off for other zones are determined accordingly. That is:

$$\frac{\text{Range to splash—normal range (for elevation used)}}{\text{normal range}} = \text{percentage range va-}$$

riation from the normal.

The ratio between any two numbers in the following table is the ratio between the per cent range variations for the corresponding zones:

Zone I,	1.93
Zone II,	1.84
Zone III,	1.80
Zone IV,	1.80
Zone V,	1.70
Zone VI,	1.40
Zone VII,	1.00

REMOVAL OF A MORTAR RACER

By 2nd Lieutenant RALPH E. HAINES, Coast Artillery Corps

The cast-iron racer of No. 4 mortar in "B" pit, Battery Best, at Fort DuPont, had been cracked during proof firing. "B" pit is the interior pit of the battery, reached by a doorway from the gallery. The racer, which was about 13 ft. 9 in. in diameter and weighed about 19 tons, could not be taken through this doorway, and therefore it was necessary to carry it over the parapet. This was accomplished as follows:

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The racer was moved to the rear of the pit and jacked up vertically on cribbing about eight feet. Four 10-inch by 10-inch timbers were laid from this cribbing to a point near the lower edge of the interior slope of the parapet, and four more to the top of the parapet. These timbers were supported by further cribbing near the interior wall. Light trolley rails

were secured to the upper surfaces of the timbers and lubricated.

Heavy shears were erected at the top of the parapet and securely guyed. Two independent tackles were rigged from the shears to the racer and the falls carried to capstans, one to the right and the other to the left of the shears. In case one tackle should have broken the other would have prevented accident. Both capstans were manned and the racer thus skidded up out of the pit.

The new steel racer was lowered into the pit in a similar manner.

THE OPERATION OF THE TRAY-LATCH

By 1st Lieutenant AUGUSTUS NORTON, Coast Artillery Corps

It is found by experiment that, when the tray-latch is removed from the tray and balanced on its hinge pin, the latch falls with the handle down. This indicates that the center of gravity is in rear of the center of motion.

It is a well known principle of mechanics that excess of weight is capable of producing motion. It is likewise known that, if a body be free to rotate about a fixed point, any force acting upon the body whose action line does not pass through the point, will produce rotation.

When, at the end of translation, the ends of the guide rails of the tray are struck by the ends of the grooves cut in the breechblock, the momentum acquired by the block is

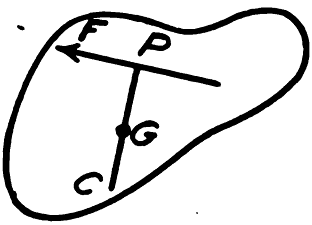


Fig. 1. 1489

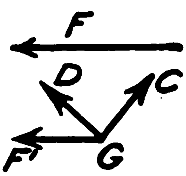


Fig 2. 1490

transmitted to the tray with an impulsive action rather than by a steady push. This impulse is transmitted to the tray-latch, and the center of gravity will begin to move parallel to the line of direction of the force applied. It is evident that the tray-latch is free to move about its axis, in a clockwise direction, when the translating roller is to the rear; but the latch cannot move to the rear.

Before proceeding further, the following points will be brought out: Suppose that a rigid lamina (Fig. 1) at rest, but free to move, is struck by an instantaneous impulse F in a given line. Evidently, G, the center of gravity, or mass, will begin to move parallel to the line of F. Let its initial velocity be u', and let ω' be the initial angular velocity. Then

$$Mu' = \mathrm{F};$$
$$I\omega' = \mathrm{F.GP},$$

where GP is the perpendicular from G to the line of F. If PG be produced to any point C, the initial velocity of the point C of the lamina will be

$$u' - \omega' . \mathrm{GC} = (\mathrm{F}/\mathrm{M})\ (1 - \mathrm{GC} . \mathrm{CP}/k^2)$$

where k^2 is the radius of gyration about G. The initial center of rotation will therefore be at C, provided

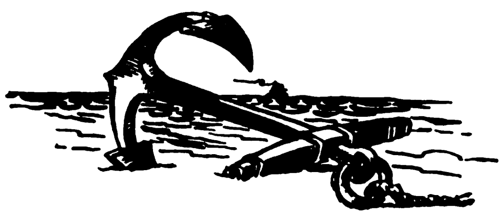
$$\mathrm{GC} . \mathrm{GP} = k^2.$$

If this condition be satisfied, there will be no impulsive reaction at C, even if this point be fixed. The point P is called the *center of percussion* for the axis at C.

It is determined by experiment that the center of gravity of the tray-latch is in rear of the center of motion and below the horizontal line through the hinge pin. The relative positions of the center of gravity and center of motion is as shown in Fig. 2.

When the instantaneous impulse F is struck in a given line, G will begin to move parallel to that line; but, since the latch is held at C, there is a tendency for G to rise to the horizontal level of C and, in fact, it will do so. This causes the toe of the latch, when the block is withdrawn and the ends of the grooves strike the ends of the guide rails, to move downward and release the tray from the face of the breech.

As stated above, there would be no impulsive reaction at C even if this point were fixed. The direction of the force F is indicated above; the direction in which G tries to move is also shown, and is parallel to the line of F. As indicated, G is held at C by the element GC, and the resultant of the two forces is in the direction of D.



COAST DEFENSE IN THE CIVIL WAR*

FORT FISHER, NORTH CAROLINA

By 1st Lieut. WALTER J. BUTTGENBACH, Coast Artillery Corps

General Situation

The coast works guarding various harbors on the Atlantic and Gulf coasts having been captured, one by one, in the attacks already described, there remained only the forts of Charleston and Wilmington in the hands of the Confederates.

The blockade of Wilmington had been maintained during the war by a naval force numbering some thirty or forty vessels, yet a large percentage of blockade runners had succeeded in getting into and out of the harbor. Because of two separate and distinct entrances to the Cape Fear River to be watched, the northern defended by Fort Fisher and the southern by Fort Caswell, the problem was one of considerable magnitude and anxiety to the Navy, a practically double blockading force being necessary.

It was of utmost importance to prevent supplies coming in, and that could not be effectually done unless the Federal forces held the entrances.

Special Situation

On September 5th, 1864, the Navy Department sent a letter to Admiral Farragut appointing him to the command of the naval force designated to attack the defenses of the Cape Fear River, wherein it was stated that the Department had, since the winter of 1862, endeavored to get the consent of the War Department to a joint attack upon these defenses, but that it had not been practicable to spare troops for such purpose. It was believed at the time of writing, however, as General Grant had given some thought to the matter, that a military force would be available about October. The naval force was to assemble at Port Royal, and the Admiral had authority to take with him, in addition to vessels specifically

* See note to "Coast Defense in the Civil War, Fort Sumter, S. C. (First Attack)," in Journal U. S. Artillery, for March-April, 1912.

designated, any vessels, with their personnel, that could be spared from the West Gulf Squadron without impairing its efficiency.

Admiral Farragut, however, on account of his health, could not take command; so he was succeeded by Admiral Porter, who was relieved for this purpose from command of the Mississippi Squadron October 22, 1864.

Opposing Forces

CONFEDERATE

Fort Fisher, guarding one of the entrances to the Cape Fear River, was situated on the peninsula between the river and the Atlantic Ocean, about a mile and a half north of the southern extremity of Federal Point—called Confederate Point in some reports. This peninsula, for some five miles north of the point, is sandy and low, rising not more than fifteen feet above low tide, and in the interior abounds in fresh water swamps, often wooded and impassible, while the dry land, beginning at a point about half a mile north of Fort Fisher, is covered with wood and low undergrowth, except for a strip about 300 yards wide along the sea shore.

At Sugar Loaf Hill, about seven miles north of Fort Fisher, was located the intrenched camp of the Confederate forces under General Bragg, concealed from the sea by forest and sand hills. From here, the river bank, because of a neighboring ridge of sand dunes, offered a covered way for troops to within 100 yards of the left salient of Fort Fisher. About half a mile north of Fort Fisher was a rise in the plain, forming a hill some twenty feet above the tide on the river side, and on this was a redoubt commanding the approach to the fort by the river road.

At the land face of the fort, the peninsula was about half a mile wide.

Fort Fisher was a powerful earthwork, having practically only two faces, its sea face about 1900 yards and its land face 680 yards long.

The land face was built to withstand the heaviest artillery fire. It had no moat, with scarp or counter scarp, as the shifting sands rendered such construction impossible with the material available. The outer slope was twenty feet from the berme to the top of the parapet, was at an angle of forty-five degrees, and was sodded with marsh grass. The parapet was not less than twenty-five feet thick with a rise of only one foot. The

revetment extended five feet and nine inches above the floor of the gun chambers, which were themselves some twelve feet or more above the interior plane. The guns were all mounted in barbette and on columbiad carriages. Between the gun chambers, containing one or two guns each, were heavy traverses to give protection against an enfilading fire. They extended out some twelve feet on the parapet and were twelve feet or more above the parapet, running back about thirty feet. The gun chambers were reached from the rear by steps. In each traverse was a magazine or bombproof, and passage-ways penetrated the traverses in the interior of the work, forming additional bombproofs for the reliefs at the guns.

The land face commenced about 100 feet from the river with a half bastion and extended with a heavy curtain to a full bastion on the ocean side, where it joined the sea face. The sea face for 100 yards from the northeast bastion was of the same massive character as the land face. A battery, crescent in shape, intended for four guns, adjoined, but was converted into a hospital bombproof, a heavy curtain being thrown up in its rear to protect it from shell fragments.

From this bombproof, a series of batteries extended for three quarters of a mile along the sea, connected by an infantry curtain. These batteries had also heavy traverses but were not more than ten or twelve feet above the water, having been built for ricochet fire.

On this line also was a bombproof for the "galvanic apparatus" connected to the submarine mines, or torpedoes. Farther along, where the channel ran close to the beach and inside the bar, the Mound Battery, 60 feet high, was erected; this comprised two heavy guns which had a plunging fire upon the channel, was connected with the battery north of it by a light curtain, and was practically the southern end of the fort. Following the line of works, it was over a mile from the Mound Battery to the northeast bastion at the junction of the sea and land faces.

On the sea face were 22 guns, as follows:

1 8½-inch rifled gun
1 8-inch " "
2 7-inch " "
5 6⅜-inch " "
8 10-inch smooth bore guns
5 8-inch " " "

On the land face were 24 guns:

3 mortars,			
2 10-inch smooth bore guns			
5 8-inch	"	"	"
7 32-pdr.	"	"	"
1 24-pdr.	"	"	"
1 7-inch rifled gun			
4 6$\frac{3}{8}$-inch	"	"	
1 4$\frac{1}{2}$-inch	"	"	

Some authorities give slightly different data.

For a plan of these works see Plate LXXV of the Atlas accompanying the *Official Records of the Union and Confederate Armies.*

There was also a loopholed palisade, with a banquette, that ran in front of the land face from the sea to the river; and in front of the palisade was a line of ground mines electrically controlled from within the fort.

A line of rifle pits that ran along a north-and-south line across the peninsula, beginning at a point north of the Mound Battery a distance equal to one fourth the sea face, partly closed the rear of the works.

From the Mound Battery for nearly a mile to the end of the point extended a sand plain, scarcely 3 feet above high tide, much of which was submerged during gales. At the point was Battery Buchanan (four guns) commanding the inlet, its two flank guns commanding also the land approach.

The fort was extremely difficult to defend against assault after its guns were destroyed. The men in the gun chambers could not see the approach in their front for 100 feet, and to repel assailants they had to leave all cover and stand upon the open parapet. The land mines extending across the peninsula were of doubtful value; and the palisades already mentioned, made of sharpened logs nine feet high and loopholed, were so arranged as to be subject to an enfilading fire in the center, where there was a small redoubt covering a sally-port from which two light guns were to be run out when needed.

The fort is said to have been far from complete when it was attacked, and especially weak against assault by land, for the side exposed to the sea was the first built, it being supposed that the forces under Bragg (the Army of Wilmington) would prevent an investment and take care of all attacks coming from the land side.

As to ammunition on hand, when Fort Fisher was attacked in December there were not over 3600 projectiles available for its forty-six guns, for the 150-pdr. Armstrong, the most effective gun, there being only thirteen shells on hand. More ammunition had been asked for, but not furnished.

The garrison varied somewhat from time to time: at the time of the first attack, December 25th, there were about 1400 men and officers in the work; and at the time of the second attack there were about 1500, of whom, though, at least 100 were not fit for duty. Additional force arrived during the second attack.

The figures given do not, of course, include the forces under General Bragg, which numbered about 6000* and were located north of the fort, covering Wilmington.

The Confederates had works also at Fort Caswell (29 guns); on Smith's Island; at Smithville; and at Reeves Point, on the west side of river. In all they had some 169 guns. There were also at various times some small Confederate gunboats on the river.

FEDERAL

In the first attack† the Federal fleet consisted of some five ironclads and fifty or more other vessels, making up a force of approximately sixty vessels, the total armament being some 619 guns. In the second attack a few minor changes were made, the grand total of guns being 627.

The land forces in the first attack, under General Butler, were bout 6500 men. In the second attack, under General Terry, there were about 8500 men.

Narrative of Events

The attacks on Fort Fisher were two separate and distinct affairs, some two or three weeks apart, and can be best taken up in proper sequence.

An attack had originally been contemplated and planned for October 1, 1864; and then, the naval force being ready and having some 150 vessels assembled, was postponed to October 15th. It was evident that a purely naval attack could not be made against Wilmington, because of the shallow water at the mouth of the Cape Fear River, the channels permitting only vessels of not more than twelve feet draught to enter. Accord-

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* See *Battles and Leaders of the Civil War*, Vol. IV, page 661.

† See *Battles and Leaders of the Civil War*, Vol. IV, page 662.

ingly, powerful influence was brought to bear, either for further delay or for the entire abandonment of the expedition. However, the vessels assembled at the outer anchorage off Beaufort, and awaited a detachment of troops necessary to cooperate in the work in hand.

On December 10th, Admiral Porter issued a general order with a chart plan of the proposed attack.* In this order "it is first proposed to endeavor to paralyze the garrison by an explosion, all vessels remaining twelve miles out from the bar, and the troops in transports twelve miles down the coast ready to steam up, and be prepared to take the works by assault in case the latter are disabled. At a given signal, all the bar vessels will run off shore twelve miles, when the vessels with the powder will go in under the forts. When the explosion takes place, all vessels will stand in shore in the order marked on the plan."

The order then sets forth the proposed positions of the vessels of the fleet, their objectives, rates of fire, etc., etc.

The *Louisiana*, an old vessel, was designed for "a torpedo on a large scale," being filled with powder and arranged to be fired. She was disguised as a blockade runner and manned by four officers and seven men.

The naval rendezvous, in order that the vessels of the fleet should not be seen by the Confederates, was fixed at a point twenty-five miles east of New Inlet.

Preparations were completed, and by December 18th the fleet assembled at the designated point, where also came the transports having aboard the troops under command of General Butler. The weather was unfavorable for operations, a gale coming up and causing considerable inconvenience to the vessels of the fleet as well as to the transports, some of which latter were running out of fresh water and supplies. After the gale, the wind changed to the westward and the sea became smooth; so Admiral Porter, wishing to avail himself of good weather, without waiting for the transports and troops, determined to go on with the attack against the batteries.

At 10:30 P.M., December 23rd, the powder boat *Louisiana* was taken in tow and piloted as near to her station as allowable; and at 11:30 P.M., having been cast off, was headed, under her own steam, towards Fort Fisher. She was anchored within 300 yards of the beach and about half a mile northeast of the

* See *Official Records of the Union and Confederate Navies*, Vol XI, page 245, *et seq.*, for orders and plan.

bastion of Fort Fisher. Fires were hauled, explosion timed for an hour and a half later, men taken off, and fuses set off. The vessel, however, blew up at 1:40 A.M., later than expected, the shock being hardly felt, and the results being nil. The experiment was an utter failure and only serves as an example of what fantastic means are sometimes made use of in military operations to achieve desired ends.

At daylight, the different divisions of the fleet stood in at low speed. At 11:30 A.M. signal was made to engage the forts, the *Ironsides* leading, followed by the *Monadnock*, *Canonicus*, and the *Mahopac*. The other lines were formed, the ships taking up their positions and anchoring; and soon the Confederate works were under fire of bursting shells of the fleet. The fort fired but little from the guns that were within range of the fire of the fleet, and maintained what seemed an indifferent fire from the more distant guns.

The firing of the fleet was conducted with deliberation, as if on target practice, the ships' guns firing at particular guns ashore and officers in the tops correcting ranges. The fire seemed fairly accurate, although it was noted that many of the shells of the outer line of ships fell short. Two magazines were blown up, and several buildings were set on fire and burned.

Admiral Porter in his report states: "Finding that the batteries were silenced completely, I directed the ships to keep up a moderate fire, in the hopes of attracting the attention of the transports, and bring them in. At sunset General Butler came in his flagship with a few transports, the rest not having arrived from Beaufort. Being too late to do anything more I signalled the fleet to retire for the night for a safe anchorage, which they did without being molested by the enemy."

The fleet suffered but few casualties due to the Confederate fire, the casualties sustained being due to the bursting of 100-pdr. Parrott rifled guns, which occurred on some five vessels, entailing a loss of sixteen killed and wounded.

Some of the fleet were damaged by shell fire of the Confederates, the *Osceola* and the *Mackinaw* were the most seriously damaged.

On the 25th the transports arrived; and, in cooperation between the military and naval forces, it was decided that the fleet should attack the forts again, while the military forces should land and assault the work under heavy fire of the fleet.

The landing of the troops was effected under cover of the

gunboats, and the fleet again closed in on the fort. The firing of the fleet was conducted with deliberation, while the fort seemed hardly to make any response. The parapets and traverses appeared torn up by the fire and so changed that they resembled the nearby sand-dunes.

Some 3000 troops having been landed, the situation was reconnoitered with a view to determine whether an assault was practicable.

The fleet kept up its fire all day, drawing off at sunset, when Admiral Porter received word that it was impracticable to make an assault.*

General Weitzel, the officer in command of the military forces ashore, and directly under the orders of General Butler, reported that on reconnaissance some seventeen guns had been found bearing on the beach, which was only wide enough for an assault of 1000 men in line; so the assault had been given up, only one gun, so far as known then, having been disabled by the Navy, after a bombardment of seven hours. The Federal line had gone to within seventy-five yards of the work; but, having in mind the awful losses suffered by an assaulting force against a line of guns at Port Hudson as well as at Fort Wagner, the troops had been withdrawn. The Federal loss was trifling, while the Federals captured about 300 Confederate prisoners in some of the smaller outworks.

General Butler reembarked his men and returned to Fort Monroe.†

The bombardment of the fleet this day had lasted some seven hours, while the bombardment of the day before was of four and a half hours duration.

Thus ended in failure the attacks so far made, and the vessels not on blockade withdrew to Beaufort to replenish their stores and ammunition and to await further orders. So far the Confederates had the advantage, the fleet having withdrawn after failure, although it had suffered but little.

Admiral Porter was directed to remain off Fort Fisher for the present and to continue, if necessary, a moderate fire to prevent any new works being built.

Before leaving this attack, let us look at it from the Confederate side for a moment.

The fleet's fire of the first day destroyed part of the quar-

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* See letter, page 224, *The Atlantic Coast*, Ammen, (Scribner Series, *The Navy in the Civil War*).

† See note page 226, *ibid.*

ters; disabled three gun carriages, damaging seriously, however, only one gun on the land side; tore up a large extent of earth works, and splintered some of the revetments, though without injuring a single bombproof or endangering any of the magazines. As no attempt was made by the ships to cross the bar, the fort fired slowly and deliberately, expending in the first day's bombardment only some 672 projectiles.

In the second day's bombardment a few more quarters were burned; more of the earthworks were damaged, but none seriously; five guns were disabled by the fire of the fleet, and two 7-inch Brooke rifles destroyed by explosion, leaving as a result of the two days' bombardment thirty-six guns still serviceable. The fort this day expended 600 projectiles.

The Confederate casualties the first day were twenty-three wounded, one being mortally wounded. On the second day there were three killed and thirty-eight wounded.* In the Confederate report it is stated that not a single gun detachment was driven from its guns.

The fire of the fleet was reported by the Confederates to have been so diffused as to do no particular damage, and to have been so wild that at least one third of the projectiles fell into the river or in the nearby marshes.

The slow deliberate fire of the Confederates gave the impression that their batteries were being silenced, but the rate of fire was due primarily to the shortage of ammunition. The Confederate commander, in order to save his ammunition, gave the order that each gun be fired only once every half hour, unless otherwise directed. After the first attack the Confederate commander asked for more ammunition, including hand grenades, and for mines to be planted where the fleet had anchored, but none of them were supplied. The fort expended in the two days' firing 1272 projectiles, leaving about 2328, exclusive of grape and shrapnel.

As a means of comparison, it is remarked that the *Minnesota* and *Wabash* each had an armament superior to the fort and that these two vessels alone fired more shot and shell than the Confederates had, all told, on hand in both engagements. The Navy rate of fire was one to two guns per second. In the first attack the total number of guns and howitzers in the fleet was over 600, and the total number of projectiles expended 20,271, their weight being over 600 tons.†

* Including those wounded by explosion of Brooke's rifles.

† See note, page 441, Vol. XI, *Official Records of the Union and Confederate Navies.*

This attack became the object of much acrimonous correspondence between General Butler on the one side and Admiral Porter on the other; while the confederate commander in his report expresses doubt as to the practicability of a successful assault at that time, the damage to the work being slight—although it is admitted that an assault pressed home might have offered some chance of success. It is a question each reader must decide for himself, the correspondence referred to merely giving one an insight into how differently military problems sometimes appear to those involved in them.

Leaving, now, the first attack, let us take up the second and successful one.

On December 31st, the Secretary of the Navy notified Admiral Porter that General Grant would immediately send a competent force (which was composed of practically the same troops as in the first attack) properly commanded to cooperate in the capture of the defenses on Federal Point. On Janurry 8th, 1865, General Terry with an army force arrived at Beaufort, and a plan of operations was agreed upon between him and Admiral Porter.* On January 12th, the fleet sailed, accompanied by the transports carrying Terry's force, which consisted of approximately 9600 men, including two field batteries. The fleet was practically the same as before, and the Confederate force also was practically unchanged.

During the night of January 12th-13th, the fleet and transports anchored some twelve miles east of Fort Fisher. In the morning the *Ironsides*, with the other ironclads got under way, proceeded to Fort Fisher, and anchored on their former range lines, as close to the works as the depth of the water allowed. This brought the *Ironsides* within 1000 yards, and the nearest monitor within 700 yards of the nearest guns, which by this time had opened up with a vigorous fire.† The vessels proceeded to get the ranges and directed an effective fire on the fort, which continued to reply with much vigor until later in the afternoon, when the heavier ships, coming into line, soon drove the Confederates into their bombproofs.

The *Brooklyn* led the first line, followed by the *Mohican*, *Tacony*, *Kansas*, *Yantic*, *Unadilla*, *Huron*, *Maumee*, *Pequot*, *Pawtuxet*, *Seneca*, *Pontoosuc*, and the *Nereus*—thirteen vessels.

* For order and plan see page 425, Vol. XI, *Official Records of the Union and Confederate Navies*.

† See note, page 62, *Artillery Notes No. 28*, giving the number of guns available for one broadside of the fleet.

miral Foote was anxiously awaiting the signal from General Terry that the assault was about to begin.

The sailors and marines having finally been gotten into position to make the assault, the signal was made at 3:00 P.M., when the vessels changed their fire to the upper batteries. Thereupon the sailors and marines began the assault on the front along the beach, while the troops charged the left flank of the land side of the fort, breaking through the palisades, which had by this time been knocked down by the fleet's fire. According to previous arrangement, all the steam whistles of the fleet were blown; and this, in connection with the sound of the shells bursting far beyond the near faces of the fort, upon which the assaulting columns were moving, gave unmistakable notice to every man in the bombproofs of the oncoming movement.

The army forces, in moving to the assault, had been placed under cover close to the land face of the fort; and from there, advancing rapidly, they gained and held the western end of the land parapet, as well as points between its traverses. But the sailors and marines had nearly half a mile before them along a line commanded by numerous guns, which swept the ground with grape and shell; and the Confederates sweeping the bastion with deadly volleys, against which no opposition could be offered by the pistols and cutlasses of the sailors, the latter found themselves helpless and were compelled to fall back.

The troops of the Federal army, having gained the parapets in their front, carried seven of the westernmost traverses without serious loss, and then attacked the traverses towards the sea, one after another, aided by the fire of the monitors, which continued to shell between the traverses and in advance of the assaulting troops. By nightfall the bastion was carried, as well as some of the traverses on the sea face, the Confederates being gradually forced back and brought under the fire of the assaulting troops in front by the ships' fire on their flank's compelling them either to abandon the traverses one after another or die in them.

The gunboats closed in on the fort and fired upon Confederates advancing to its relief, stopping them, while the assault by the Federal land forces kept on, the naval force joining the troops of the Army. Shortly after ten o'clock that night all resistance in Fort Fisher ceased, the Confederates abandoning the work and retreating towards Battery Buchanan, where at midnight a remnant surrendered.

The Federal assault on the land front was made by three deployed brigades, following one another at 300 yards, the strength of troops engaged being 440 officers and 8457 men, with 10 guns. The loss suffered was 10 officers killed and 47 wounded, and 100 men killed, 489 wounded, and 13 missing. Other reports give slightly different figures.

In the unsuccessful assault made by the sailors and marines there was a loss of 82 killed and 269 wounded.

The expenditure of ammunition in the fleet in the second attack was estimated to have been 19,682 projectiles, weighing 1,652,638 pounds.*

Considering the second attack from the point of view of the besieged, we learn from the Confederate reports that during the bombardment of the 13th and 14th considerable loss was inflicted on the works, only three or four of the guns on the land side remaining serviceable. The fort commander made attempts to get in touch with General Bragg but was unsuccessful. On the night of the 14th, for instance, a reconnaissance was made by one company, when the Confederates discovered that Federal troops occupied the redoubt; and though they awaited news from General Bragg till daylight, none came.

On the same night 500 men were added to the Confederate garrison by way of the river, making a total of about 2300 men, defending a line some 500 yards long. The Confederates soon saw, however, that they could not hope to successfully attack the Federal forces, on account of their position and the covering fire of the fleet.

On the 15th the fleet again opened fire, and by noon there remained but one serviceable heavy gun on the land front; while the number of dead and wounded increased to such an extent that there were left fewer than 1200 men to defend the works. Hagood's Brigade, sent by Bragg, arriving at Battery Buchanan, succeeded in landing only two regiments of a strength of 350, before the transport was driven off by the fire of the fleet. This reenforcement reached the fort thirty minutes before the attacking column struck it.

In the Confederate reports it is said that the fire of the fleet was more concentrated than in the first attack, appearing to have as its definite object the destruction of the land de-

* See note, page 441, Vol. II, *Official Records of the Union and Confederate Navies*, and for a more detailed record see pages 258-260, *The Atlantic Coast*, Ammen (Scribner Series, *The Navy in the Civil War*).

fenses by enfilade and direct fire, for which purpose the fleet selected its position. In the bombardment, the land defenses of the work were practically destroyed, the palisades being breached and the slopes rendered practicable for an assault; but not a bombproof or a magazine was injured; all heavy guns on the land face except one were disabled, the palisades so badly battered up and cut down that they furnished no protection to the defense, rather a protection to the assailants instead of a formidable obstacle. The Confederates ascribed their retreating to being out of ammunition and to the impracticability of help's reaching them from the outside.

The Confederates surrendered 112 officers and 1971 men —their casualties during the second attack having been about 500 killed and wounded.

Upon the surrender of Fort Fisher, the defenders of the other works at the mouth of the Cape Fear had the alternative of surrendering also or retreating; so by the night of the 16th the other Confederate works were abandoned and blown up. The Navy took possession of them and exercised complete control of the waterways to Wilmington, thus closing another Confederate port, the last importing depot of the South, thereby cutting off further supplies from Europe, and ending all blockade running, except such as was still possible at Charleston.*

Comments

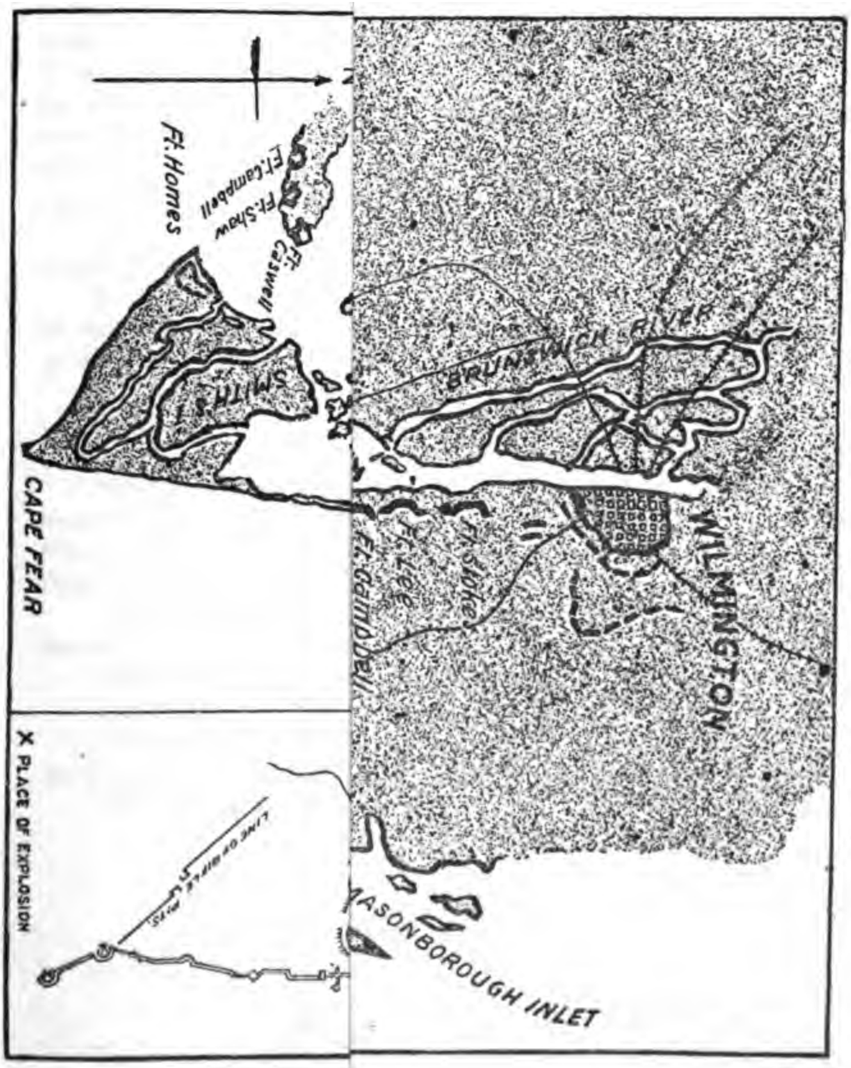
1. In the attacks described, we have lack of cooperation between Army and Navy in the first, contrasted with successful cooperation in the second; and the contrast is the more interesting because the difference was wrought merely by a change in command.

2. In the first attack we observe a dispersed, or objectless, fire—scattered, apparently, all over the fort—which, as usual, was found quite useless; while in the second attack we see a definite plan adopted, with concentration of fire. This serves to mark what may be considered the first rule in the use of artillery, one that cannot be brought out too forcibly, that concentration of fire is absolutely necessary to accomplish definite results.

3. The general alarm, as it were, before starting the as-

* Of the well known "explosion," the place of which is indicated on the chart reproduced with this article, no mention has been made in the body of the article, because it occurred on the morning of January 16th, following the surrender of the fort.

'ry, *July-August, 1914.* To face page 82.



Artillery Notes No. 28.

1401

sault, virtually served notice on the fort that an assault was coming. Or one is reminded of the children of Israel before Jericho.

4. Fort Fisher affords an example of an overstrengthened work, being virtually a large bombproof, tempting the garrison to reliance upon it for refuge, in utter neglect of the effect of an assault. A land attack must be met at the landing; for if the attack secures a foothold while the defense remains behind cover, it is highly problematical if the attack can be effectually resisted later. This is especially true, because operations of the kind are generally aided by the fire of a fleet.

5. We observe the familiar condition of a shortage of ammunition in the fort.

6. The failure of the troops under Bragg outside the fort, to cooperate, was the cause of the loss of Fort Fisher; in fact, of the loss of all the Cape Fear River defenses.

9. An example of a naval bombardment *at anchor*.

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PROFESSIONAL NOTES

COAST DEFENSE

By Brigadier-General R. M. B. F. Kelly, C.B., D.S.O.,
Commanding Royal Artillery, Southern Coast Defenses

Part I.—Evolution of Modern Coast Defense Policy

EARLY CONCEPTIONS OF COAST DEFENSE

Coast defense no longer denotes what is implied by the words, and before an explanatory description of it can be given it is necessary to refer very briefly to the origin and history of the term.

Coast defense as part of the military organization of the country is not very old; it was, in fact, called into existence by Napoleon's threat of invasion in the early years of the last century, and disappeared when that threat was removed. The Tudors, Stuarts and Commonwealth did not attempt to safeguard England by a chain of forts all along the vulnerable coasts; they defended strategical points, as we do now, but the panic caused by fear of invasion in the first decade of the last century was a very real one, and called forth strenuous efforts and heavy expenditure to allay it. The expression "coast defense" has been bequeathed to us from those days; but it is only the name, and some semi-ruinous martello towers along the south coast that have been left.

There is a touch of irony in the fact that we actually employed the man who, in 1790, elaborated a plan for the invasion of England from Cherbourg to work out a scheme of defense against his own plans. Dumourier is the author of the original form of coast defense. His scheme was to provide an almost continuous line of fixed defenses along our vulnerable coasts from the Wash to the Tamar; these works were to form, as it were, the sentry line, behind which in the form of selected camps or fortified posts were three successive lines, corresponding to the piquets, supports and reserves of the outpost lines of those days. The complete revolution that has taken place in the conception of the functions of coast defense since those days is well illustrated by the fact that while Dumourier dwelt at length on the defenses for the coast line at Rye, Hastings, Brighton, etc., he dismissed the defenses at Portsmouth in very few words, adding that "the fleet would be able to secure the safety of the shore at Gosport and Portsmouth."

DEVELOPMENT OF COAST ARTILLERY TECHNIQUE APART FROM DEFENSE POLICY

This elaborate scheme of extended and continuous weakness naturally disappeared after Trafalgar and Waterloo, never to be revived. When the next scare, about 1848, turned attention once more to the vulnerability of our coasts, the policy of a continuous chain of martello towers had been abandoned and had given place to a scheme of fortification of certain har-

bors. Coast defense became what it now is, and what it ought to be called —harbor defense. From a strategical point of view this was a great gain; it was practically admitting that the inviolability of our shores depended on an active not on a passive defense, that to attempt to defend the whole of our vulnerable coast line was simply wasting our strength without gaining any security, or any immunity from the real danger that threatens us in war—starvation. But the records of the defense policy of those days, indelibly written in the vast and costly granite and armored works surrounding our dockyards, show that the appropriate rôles of Army and Navy in the defense of the Empire had not been coordinated. The scale of fortifications and armaments had apparently been laid down without any reference to naval authorities, without due consideration of the naval rôle in the defense of the Empire, or of the offensive limitations of war ships in attacking fixed defenses. The idea governing the defense works of the Palmerston era was still prevention of invasion; the casemated works on the land side of our coast fortresses were *points d'appui* from which flank attacks could be made on attempts at landing in the intervals.

Apprehensions of invasion or of oversea attack on important harbors were allayed by lavish expenditure on masonry and on armored counterparts of the ships of the period armed with rows and tiers of muzzle loading guns firing through port-holes over very restricted arcs of fire.

The increasing power and range of guns demonstrated the vulnerability of these conspicuous forts, and the waste involved in crowding guns together with limited arcs of fire; and the bombardment of Alexandria showed the comparative immunity enjoyed by well concealed and dispersed guns.

So the old fashioned casemated forts gave place to dispersed batteries each mounting a small number of well-concealed guns; accurate means of range-finding and a recognition of the value of height as a factor in range and accuracy led to a further dispersal of guns, while enabling the fire of the guns so dispersed to be concentrated. This rearrangement of guns necessitated a careful organization of units, duties and chain of command in the coast defense artillery, and led to the organization of the defenses of a harbor into a definite defense unit—called a coast fortress—and its subdivision into sections, and, so far as the fixed artillery armament was concerned, into fire commands, battery commands and groups of guns. The constant progress in the scientific development of guns and their mountings, ammunition, and in means of range finding, and communication of ranges and corrections; improvements in sights and sighting arrangements, and in the calculations of range and deflection corrections for variable causes affecting ballistics; the increased size and speed of ships and new elements of offense and defense—such as submarine mines, torpedoes and torpedoboats and submarines—all necessitated changes in the arrangement and organization of coast defenses. But the developments of naval and military, active and passive, means of defense tended to run along separate lines without proper coordination, and were even in some cases antagonistic; and while the danger of attack from the sea was exaggerated the vulnerability of the land side was often ignored. The policy governing the whole question of coast defense, its relation to naval strategy, the requirements of the Navy and the protection of the Empire generally had not been formulated.

PERCEPTION OF THE TRUE FUNCTIONS OF COAST DEFENSE

It was probably the writings of the celebrated American naval officer

Captain (now Admiral) Mahan that first directed public attention to the vital importance of sea power, and brought home to the minds of Englishmen the conviction that not only the safety but the very existence of our island Empire, with its wide flung Dominions and dependencies, must depend on naval supremacy; that no amount of fixed coast defenses could save us from starvation, if our oversea communications were cut. As a consequence of the realization of these facts, the true functions of coast defense began to be formulated, and the present basis of coast defense, its scope, and the nature of the attacks to which it is deemed to be liable, rest on the following axioms arising out of these views:—

(1) That the immunity of the United Kingdom from invasion and the safety of the Empire must depend on naval superiority.

(2) That the protection of our seaborne commerce is essential to our existence, and that this also can only be obtained by naval predominance along the ocean routes.

(3) That the safety of our scattered Dominions and dependencies depends on our being able to keep open our lines of communication with them.

To ensure these three requisites, a Navy more powerful than that of any probable combination of Powers opposed to us is the first essential; but to secure the efficiency of the Navy and to enable it to act on the best strategic lines and also to keep open our ocean communications, it is necessary that it should have at its disposal dockyards, harbors of refuge and coaling stations secure from any attack likely to be brought against them.

We thus arrive at the broad outlines of coast defense—the protection of naval dockyards, harbors of refuge and coaling stations; also, although the protection of seaborne commerce can only be secured by naval action, yet it is desirable that important commercial harbors should be secure from the attack of a chance cruiser. There may also be places whose capture or threatened capture would be of such political importance that they should be protected, if assailable from the sea.

TYPE AND DEGREE OF DEFENSE REQUIRED

Having determined on the places to be defended, it is next necessary to consider the degree and kind of defense requisite. Again Captain Mahan's writings have helped to clear up conflicting ideas as to the degree and nature of defense necessary, directing attention to the lessons of history as to the rôle played by navies in the past; to the limitations of naval power opposed to fixed defenses, on the one hand, and of fixed defenses in keeping open communications unless supported by a powerful navy on the other hand. The study of Captain Mahan's works, those of Sir G. Clarke (Lord Sydenham) and of others who have followed him, and of the history of naval warfare, enables us to formulate certain bed-rock principles to govern the type and degree of defense that should be provided.

(*a*) *Against Attacks by Ships*

(i) *Coast Fortresses at Home.*—The principles of naval strategy are to seek out the enemy's fleet, to meet it with superior force, and to destroy it. This may entail temporary and local loss of command of the sea and expose coasts and coast fortresses to attack. But ships are designed to fight other ships and not land fortresses, and the strategic principles of the enemy must be the same as ours (*i.e.*, to concentrate so as to meet our fleet or detached

squadrons in superior force, or to "contain" ships or squadrons in harbor so as to prevent such combination on our part). Their primary ships (battleships and armored cruisers) are, therefore, unlikely to risk encounter with shore guns unless there is a real probability of their being able to inflict greater damage on us by such action, and unless the result would have some direct effect on the course of the war; and even then, primary ships would not be risked if the same result could be obtained by the exposure of less valuable matériel and of ships more easily replaced.

In an action with fixed defenses ships are in many ways at great disadvantage. The shore guns have stable platforms, they can be dispersed and yet bring a concentrated fire to bear on any one ship, they have the advantage of high site, accurate range finding, and good observation; they offer a less conspicuous target, and have, comparatively speaking, an unlimited supply of ammunition. The old-fashioned casemated forts were conspicuous, and could nowadays be easily overwhelmed with fire and destroyed by ships out of the arc or range of their guns. But modern defenses consist of small open batteries of single groups of guns; the batteries are placed at a considerable distance from each other and are yet able to concentrate their fire; they are high sited and inconspicuous, and form a difficult target to attack; the guns can successfully rely on accuracy and rapidity of fire for their protection, and can dispense to a great extent with armored protection (except splinter-proof shields for the protection of the numerically small number of men exposed). Such works, provided with guns even far inferior in range and shell power to those carried by ships, are capable at long ranges of inflicting such an amount of secondary damage on ships engaging them that, as shown by recent history, even battelships and armored cruisers are very chary of coming within range of well sited and well found guns of much smaller caliber than what they themselves carry; while for unarmored cruisers to come within range by day would be to court destruction. Furthermore, the destruction of coast defenses cannot in itself be a primary object of any naval action; and it would therefore seem that an engagement with coast defense guns would only be undertaken in order to destroy the ships or docks they protect, or to force the passage of a maritime canal or strait.

A consideration of the above would appear to lead to the conclusion that the guns of the fixed armament should be sufficient in number and caliber to deter an enemy's fleet or individual ships from coming within their range to attack the ships, docks or fuel protected by them; and the arguments for this limitation of scale appear to hold good for all coast defenses in waters where the command of the sea is a vital necessity to our existence.

(ii) *Colonial Coast Fortresses.*—Coast fortresses more remote from the heart of the Empire may have to be left to their own unaided efforts for more or less lengthy periods and, if their capture offered a sufficient inducement, an enemy might be prepared to risk damage and possible loss in an endeavor to capture the place—if they could do so without fear of interruption. In such cases a more powerful fixed armament would appear to be justified; but again the lessons of history show that when a coast fortress, the fall of which has meant the loss of the colony or possession, has been captured, it has succumbed to a landing attack or to a combined attack, and not to an attack from the sea alone.

(b) *Against Attacks by Land*

The vulnerability of coast fortresses from the land side, and the necessity of providing them with adequate troops to repel such attacks, had been to a great extent ignored till the middle of the last Century.

(i) *Coast Fortresses at Home.*—A raid by a landing force on one of our coast fortresses at home, with a view to inflicting serious damage on docks and shipping after surprising the garrison and before reinforcements could arrive, is conceivable; but a deliberate attack could only be carried out by the landing of a force of such dimensions that it would constitute an invasion; it would be met by the whole mobile defensive forces of the Kingdom, which would have to be defeated before the attack on the fortress began. The defeat of these forces would probably effect the enemy's object without any further necessity for attacking the coast fortress; so that, logically, a home coast fortress is not likely to be subjected to a siege or to deliberate attack by a large force; and this can be taken into consideration in estimating the scale of landward defense.

(ii) *Colonial Coast Fortresses.*—With colonial coast defenses, however, the case is different; they may have to rely on their own resources for a considerable time; and, if of importance, must be adequately defended on the land side to be able to repel any expeditionary force likely to be brought against them.

(c) *Against Raids by Torpedo Craft*

The development of torpedoes and toredpo craft has, however, exposed our ships in harbor and docks to a much more formidable danger than deliberate attack, bombardment or landing attack. Without special and very complete defense against this new form of attack our ships would be exposed to total disablement, at a very small risk to the enemy, when lying in harbor or dock within the radius of action of such craft.

RECENT PROGRESS: CLOSER COOPERATION OF THE TWO SERVICES

At the close of the last century our coast defenses were determined on the considerations that have just been given. The defense of the Kingdom and of the Empire generally was secured by naval predominance; coast defenses were provided to meet naval requirements and to give the Navy security during much-needed periods of rest.

The armament provided consisted of:—

(1) Heavy guns, and in some cases high angle fire guns to keep hostile ships at a distance.

(2) Submarine mines and dirigible torpedoes to prevent the passage of narrow waters and to prevent ships from taking up, under cover of darkness, positions at close range from which, by virtue of their more numerous and heavier guns, they could smother the shore defenses with fire.

(3) A complete protection against torpedoboat raids, by means of breakwaters, with narrow entrances, across which floating obstructions (booms) were placed, completely closed at night; light quick-firing guns; and electric lights.

(4) A land defense consisting of an allotted infantry garrison and some mobile guns occupying prearranged defensive positions.

But although naval requirements had been considered in the broad outlines of the policy and scope of coast defense, yet in carrying out details,

there was very little cooperation. The responsibilities of the two services for various portions of the defense were not laid down, and even between different branches in the Army there was a lack of cooperation, and a want of demarcation of duties. The Royal Engineers had charge of the submarine mines and electric lights, but although their plans and proposals for mine fields were submitted for Admiralty approval, there was not that joint working of the services for regulation of traffic in defended harbors which would be absolutely necessary for the safe working of a mine field; the electric lights were installed partly with regard to the mine field and partly with regard to artillery fire, but the Royal Engineers—not the Royal Artillery—controlled the manipulation of the lights; the Navy gave no definite assistance in the local defense beyond the provision and placing of booms and floating obstructions; and, except in colonial fortresses, the land defenses—although provided with a garrison—were not organized nor was the local commander in peace necessarily, or even probably, the fortress commander designate in war. Each separate branch was developing very great efficiency along its own lines, but a coordination of all the separate branches into a harmonious scheme of defense had still to be worked out.

In the artillery the change from muzzle to breech loading guns, the introduction of quick-firing guns, smokeless powder, improvements in sights and sighting telescopes, range finding instruments, and communications, enabled one gun to do the work of about ten old muzzle loading guns, and up to the limits of the electric light enabled fire to be carried out as accurately and nearly as rapidly by night as by day. The reduction in the number of guns, the fact that they were grouped in small scattered batteries, and that the range finders were not always close to the guns, required a careful arrangement of chain of command of units, and of duties and responsibilities, out of which has grown our present organization. The advent of the submarine and the assumption by the Navy of cooperation in the defense led to the abolition of military submarine mining as a part of harbor defense. The sphere of action of a submarine mine field was very much restricted not only by the limits of the power of vision (observation) but also by considerations of expense, which in the matter of submarine cables increased almost in geometric progression with the distance of the mines from the observing station. The depth of water, currents, tides and nature of bottom also affected the choice of mine fields, and an active mine field (except in the case of observation mines) was a source of inconvenience, if not of danger, to vessels using the port. The submarine boat on the other hand, carried the power of the mine field to an ever increasing radius, and in its present development it not only is a powerful deterrent to a ship from approaching within range, but would also tend to prevent a blockade.

The transfer of submarine mining from the Royal Engineers to the Royal Navy marked the final stage of the evolution of modern coast defense, and it may be of interest to recapitulate the successive stages.

RECAPITULATION OF PART I.

1. A passive defense of our shores against invaders.
2. The defense of certain harbors against oversea attack, without any well defined policy as to what should be defended.
3. A well defined policy as to what should be defended and the extent of defense necessary, but a lack of cooperation in the carrying out and organization of the defense.

4. Coast fortresses as separate units, the allotment of definite garrisons, sub-division into sections and smaller units and general organization of their defense.

5. Lastly, cooperation of Army and Navy in general defense policy. Imperial Defense Committee—and in the special defense of home ports—Home Defense Committee. The division of responsibility between Army and Navy in the defense of a coast fortress, and allotment of services to each branch of the land forces.

Part II.—The Defense of a Coast Fortress

Classes of Attack to be Expected

The selection of places to be defended and the scale of defense for each is settled by the Defense Committee. The scale naturally depends on the importance of the place as a factor in war, and the class of attack to which it is liable, the latter depending to a great extent on its geographical position. The different classes of attack may be summarized as follows:—

1. Deliberate attack by primary ships.
2. Bombardment.
3. Attacks by blockers to prevent egress.
4. Torpedoboat raid assisted by boom smashers.
5. Attack by protected or unarmored cruisers.
6. Land attack.
7. Reconnaissance or attack from the air.
8. A combination of any of the above.

There is not space in a single article to consider in detail all the forms of attack to which our various fortresses are liable; but in accordance with the reasoning I have before outlined, it is fair to assume that as the command of the sea in home waters is a vital necessity, our home fortresses are less likely to class of attack (1) than are, say, Gibraltar or Malta; and that a coaling station on lines of communication would only under exceptional circumstances be liable to this form of attack, although it is conceivable that—if inadequately defended—it might be so attacked by a ship or ships in need of coal.

Long distance bombardment is a doubtful form of attack, although the fact that some foreign battleships now carry guns capable of high angles of elevation, and the possibility of using aircraft for observation make this form of attack less improbable now than formerly. An attempt to prevent the egress of a fleet from harbor by blocking the fairway either by sinking a vessel in it or by mining was resorted to in the Russo-Japanese War and is a probable form of attack in future wars. The capture of a colonial fortress which would involve the loss of the colony would be such a blow to our prestige that it might easily form a primary object in war; the attack would probably be from the land side, supported by a bombardment or deliberate attack from the sea.

Organization of a Coast Fortress

The responsibilities for defense are divided between the Navy and Army. The former are responsible for the placing of sea obstructions; for mining—if it should ever be required; for keeping the fairway clear of hostile mines by sweeping; for acquainting the military authorities with intelligence received from naval sources; and for regulating the traffic within the port.

Duties and Organization of Land Forces

The land forces are charged with the land defenses both seawards and on the land side, and with the protection of naval obstructions.

(i) *The garrison* of a coast fortress is divided into (*a*) coast defense troops and (*b*) troops for general defense.

(*a*) *The coast defense troops* consist of Royal Garrison Artillery coast defense companies, Royal Engineers electric light companies, and a few Ordnance Department artificers attached to the Royal Garrison Artillery. The troops supplying them are usually the Regular units stationed in the command in peace time, augmented in war by reservists and, at home, by specially allotted Territorial units.

(*b*) *The garrison for general defense* consists of mobile guns manned by Royal Garrison Artillery Regulars abroad, and by Territorial field and garrison artillery at home; Maxim machine guns manned by infantry and in some cases by Territorial garrison artillery; Regular, Special Reserve, and Territorial engineers and infantry; Territorial cyclist sections, and Yeomanry. At colonial fortresses local volunteers take the place of Territorials in supplementing the Regular Forces.

(ii) *As regards the different arms of the service.*—The artillery are charged with the artillery defense fixed and mobile, and they control the tactical use of the electric lights; the Royal Engineers with the upkeep of works and buildings, the planning, and—in many cases—with the execution of obstructions and temporary defense works on land; the production of electricity and actual manipulation of the lights, signalling and telephone services (except artillery command lines), and the upkeep of electrical lines generally, except where this service is performed by the General Post Office; the infantry and Yeomanry, if any, are charged with patrolling and intelligence duties on land, defense of the land side, and the immediate defense of batteries and vulnerable points against attack from the land side or landing attacks.

(iii) *The command* of a coast fortress is in the hands of a specially selected officer, "Commander Coast Defenses," who in war becomes the fortress commander, assisted by a C.R.A., a C.E.,* a General Staff officer, an officer of the Q.M.G.'s branch, and the usual heads of departments. A large fortress is divided into sections, each commanded by a section commander assisted by two staff officers—one for General and the other for A.G. and Q.M.G. staff duties—a C.R.E.* and departmental heads. Generally speaking, the section commander exercises full command over all the land service portion of the defenses of his section, and is responsible for the administrative services; but there are certain services—such as examination and control of mercantile traffic, communications, administration of martial law, etc.—which are common to more than one section or which, for other reasons, have to be administered under the direct orders of the fortress commander. It is usually convenient that the defense of the land side should form a separate section.

(iv) *For artillery purposes* the fortress, or each section having seaward defenses, is divided into fire commands. For the sake of unity of command the boundaries of sections must be drawn so as to include entire fire commands. A fire command (F.C.) is the highest regimental unit of coast artillery, and corresponds to a battalion of infantry; it consists of those

* "C. E." denotes the chief R. E. officer of a fortress; "C. R. E." of a section; thus a large fortress might have one "C. E." and three or more "C. R. E.'s"

batteries which are intended to cover one area of water or the entrance to a particular port, and includes the artillery garrisons of those batteries, and infantry detachments allotted for their immediate defense, or for the defense of vulnerable points in artilllery charge.

The fire command is divided into battery commands. A battery command (B.C.) consists of a group or groups of guns bearing over the same area; its extent must not exceed that which can be efficiently commanded by one officer.

A battery is divided into groups, each commanded by a gun group commander (G.G.C.). A group usually consists of two, or at most three, guns; the guns of a group must be of the same nature and caliber, mounted the same height above sea level, and the group must have separate gun and ammunition stores. Groups of anti-torpedoboat guns are not formed into batteries, but their gun group commanders have the same duties and responsibilities as the battery commanders of medium and heavy guns.

Range finding instruments ("position finders") are often outside the battery whose guns they serve, but come under the orders of the battery commander. Similarly look-out or other detached posts, even if situated in another fire command, come under the orders of the fire or battery commander for whose guns they are intended.

(v) *The fixed artillery armament* is divided into heavy, medium and light; the heavy armament consists mainly of 9.2-inch guns.

The light guns, 4.7-inch, 4-inch, and 12-pdrs., are intended to deal with torpedo craft.

Maxim guns are provided for the immediate defense of vulnerable points and batteries, and infantry detachments are detailed for the same purpose.

All guns on fixed mountings are provided with accurate means of range finding, viz., position finders, depression range finders, or automatic sights—the description of these appliances is too technical for insertion in a general article.

(vi) *Electric lights* are provided for illuminating the entrances or water areas across which the attack must pass. They emit either concentrated or dispersed beams, the spread of the fan of light being from 16° to 45°; they are used either (1) as *fixed lights*, forming a pencil of light (concentrated beam) across which the enemy must pass—these are called sentry beams—or several dispersed beams combined to light up an area of water (illuminated area); or (2) *movable lights* to search out a dark patch of water (search lights), or to light up a vessel under attack (fighting lights); these may be concentrated or slightly dispersed (16°). The effective radius of lights of the same candle power depends on the degree of concentration. The lights though kept burning can be screened (doused) at will. The tactical control of the lights is exercised by the battery commander for whose guns they are installed, by means of orders to an engineer officer termed the Electric Light Director, who either manipulates the lights himself, by means of electric motors, or gives orders to the light detachment of Royal Engineers. In some cases the control of a fighting light is exercised by the fire commander, and when the latter turns the light on to and follows a vessel, this is a signal to his battery commanders to engage her.

ARRANGEMENTS MADE IN PEACE TIME FOR DEFENSE

The whole of the arrangements for the defense have to be worked out in peace time, and the following facts have to be taken into consideration:—

The strategical importance of the fortress; topographical conditions; strong and weak points; forms of attack to which liable, and best methods of meeting them; action to be taken by heads of departments on mobilization; detail of garrison accomodation; details of electric lights; communications, etc. Many other arrangements have also to be thought out in peace time and put on record, so that the commanders, staff and garrison can pick up the details of organization at once. Details as to mobilization, billeting, transport, railway, sanitation, administration of martial law are discussed by a mobilization committee which meets quarterly, and its decisions are suitably recorded so as to be readily available.

(a) For Defense Against Ships

As regards the coast artillery, records are kept up for every work—giving all the details of the work and its armament and stores, and all the necessary plans, charts and topographical details as well as all the gunnery tables and data requisite for the efficient fighting of the work and ranging of the guns. Extracts from these records, containing memoranda likely to be useful to a commander in action, together with diagrams and tables to aid him in selecting the most suitable projectile and the best point of impact when attacking ships of different classes, are compiled and kept up to date by or for every fire commander, battery commander, and gun group commander.

In a fortified harbor there must also exist well organized means for the admission of friendly vessels and the exclusion of vessels that, under the guise of friendly merchantmen, may be seeking admission with some sinister design; and regulations for traffic, so as to prevent the fouling of the fairway, or the leakage of intelligence—whether by accident or design.

Special regulations have been approved governing the entry of war vessels and merchantmen. These include:—

1. The issue of notices to mariners at the beginning of every year warning them that the examination service may be enforced at any of the named ports without previous warning, and giving information as to the signals indicating this, or that the port is wholly closed, and instructions as to what they are to do.
2. The provision of a fixed water area called the examination anchorage.
3. The examination service, consisting of one of more harbor tugs or similar vessels constantly on duty, the examining officer and pilots, etc.
4. The examination battery.

(b) For Defense Against Attacks by Land

The land defense of a coast fortress includes:—

Provision against attack from the land side.
The immediate defense of batteries and vulnerable places.
Defense against landings from boats.

It is provided for by a specially allotted infantry garrison with cyclist and Yeomanry detachments; by mobile guns; by maxims, over and above those held on regimental equipment; by Royal Engineers; and by the usual departmental services.

The arrangements that have to be made in peace time include: command and staff of sections; allotment of accommodation and defense distribution of garrison; selection of defensive positions; allotment and position

of general reserve; action to meet various forms of attack; signalling and lines of communication; engineer services; preparation of defensive positions to be carried out on mobilization, including provision of working parties; ordnance services; supply of materials and tools for placing the posts in a state of defense; completion of ammunition supply; equipment of war shelters in the coast defense batteries; supply and transport services, including the rationing of detached posts, transport of mobile guns, ammunition and stores, water transport, medical and sanitary services.

War station orders for each of the defensive posts are made out giving the commander of each such post—who may be absolutely unacquainted with it—all the information he would require as to putting his post in a state of defense, and the duties he would have to carry out with his garrison.

METHODS OF DEFENSE AGAINST VARIOUS FORMS OF ATTACK AT OUTBREAK OF WAR

The forms of attack to which a coast fortress is liable vary not only with the nature and position of the fortress, but also with the period of the hostilities. At the outset, for instance, when the command of the sea is indeterminate a deliberate attack is very unlikely, while raids and blocking attacks are extremely probable.

There is only space in this article to sketch in lightly the attacks that may reasonably be expected to be made on the defenses of an important home fortress at different stages of hostilities.

(a) Against Enterprises of Hostile Agents

Hostilities may precede a formal declaration of war, but would hardly be likely to break out without a previous state of strained political relations. During this period, especially if our opponent had determined on war, it is likely that attempts at mischief would be made by individuals, directly or indirectly in the pay of the enemy's secret service, such as spying and transmission of intelligence, cutting electric lines and cables, tampering with shore ends of submarine cables, blowing up railway bridges, culverts or tunnels, damaging waterworks, electric light installations, etc., etc.; such attacks would not be military operations in any sense of the word; they can best be prevented by precautions taken in peace—such as the insistence on the confidential nature of all defense works, the protection of vulnerable points against access or near approach by means of fencing, the employment of cables instead of air lines in all fortress communications, and the duplication of important lines. When relations once become strained the prompt adoption of precautionary measures, active patrolling and police work form the best preventive means.

(b) Against Land Attack by a Raiding Force

Although a deliberate attack is not likely at the outset of hostilities, the landing of a raiding force of from 5000 to 10,000 men within 24 to 48 hours' striking distance of one of our dockyards with a view to destroying docks and ships fitting out and of creating panic would, not improbably, be attempted. The essentials to secure the success of such a raid would appear to be:—Firstly, surprise (the raid might be coincident with the declaration of war; the raiding force and its transport could be collected under some specious pretext and the transit could be effected under cover of darkness). Secondly, a safe and easy landing place close to—if possible within 20 miles

of—the objective, and within a night's steaming of the point of departure. Thirdly, a force lightly equipped, unencumbered by any but a few field guns, prepared to live on the country, and ready to sacrifice itself.

The garrison for general defense of a coast fortress will always be small compared with the perimeter which they have to defend, as it is obviously bad policy to lock up more men than are absolutely necessary in a place that may never be attacked, while as large a striking force as possible should be kept in central positions ready to meet an attack anywhere.

Thus the defensive position covering the fortress must not be pushed out far, and active enterprises at a distance should not be expected from the garrison; but cyclist or Yeomanry patrols would be pushed out to watch all possible landing places within striking distance. Reinforcements would always be forthcoming within 24 to 48 hours, so that delaying action must be the rôle of the garrison.

The progress of a body of troops in a hostile country must always be slower than in a friendly one, and in an enclosed country like England, serious delay can often be easily imposed in a very short time—by the felling of a tree, for instance, to block a road. The raiding force would count on the suddenness of the attack finding the defense unprepared and the defense works incomplete; but as the attack is unlikely to be accompanied by artillery heavier than field howitzers, it would probably have to occupy a position within at least 5000 yards of the dockyard itself, and would then have to be secure from interruption for some little time before it could effect considerable damage; and unless it could secure this position within about 36 hours of landing it would have to meet the troops of the central force. If the weather was suitable for the enemy's torpedo craft to elude our own, it is possible that this landing attack might be accompanied by a torpedoboat raid, in the hope of finding the booms not laid out and the sea defenses unprepared.

The best defense against such raids is careful preparation and organization in peace time, and the timely carrying out of such precautionary measures as can be adopted in a state of peace and without mobilization (which might in itself precipitate hostilities and be, therefore, undesirable). Defense posts should be occupied, as far as the peace garrison will allow, and put in a state of defense; and all preparations for defense which can be made without destruction of private property should be put in hand; scouting patrols should be sent out, and intelligence services organized; and, without unduly pushing out the line of resistance, it should be possible to delay the enemy by making him deploy at a considerable distance and by disputing the intervening ground up to the defensive line, where a stubborn resistance should be made.

(c) *Against a Torpedoboat Raid or Attempt to Block a Fairway*

The torpedoboat raid would only differ from such raids at other periods of hostilities in that it would probably be unaccompanied by boom smashers or supporting cruisers. It would rely on surprise and on the enemy's unpreparedness. A boom smasher would probably not be required, and the presence of larger and probably slower vessels would imperil the element of surprise.

Another probable form of attack at this period would be the blocking of the fairway by sinking a vessel in a narrow part of the channel, or by mine laying. The blocker's tactics would be to approach the entrance

under the guise of a merchant vessel or barge coming in for merchantile purposes, come up as far as possible, and sink herself in a narrow part. The best defense against this is the early establishment of the examination service, and strict enforcement of the regulations for traffic; once the vessel is detected the artillery of the defense must sink her as far out as possible. To sink her after she had got into a narrow part of the channel would be to play her own game for her; it is, therefore, essential that the long range heavy guns should be ready for action at all hours whenever hostilities are imminent or possible, and that the defense lights should be kept running.

The mine layer would not be under the same necessity of running in close; mines dropped even at some distance from the entrance, carried to and fro by the ebb and flow of tide, would form a very dangerous menace to vessels using the harbor, so that the mine layer's operations could be carried out beyoud the range of the shore guns, and should be dealt with by the extended defense.

METHOD OF DEFENSE AGAINST TORPEDOBOAT RAIDS AT ANY PERIOD OF WAR

The case of a torpedoboat raid at the outset of war has already been considered, but such raids are, perhaps, the most likely form of attack at any period of hostilities. A successful attack might inflict irreparable damage at a comparatively trifling risk. The essentials of success in this form of attack are surprise, a knowledge of the harbor and its approaches, strength in numbers of boats (which should exceed the numbers of guns that can be brought to bear), and well concerted simultaneous action. The attack would possibly be accompanied by some stoutly built vessels to break through the boom (boom smashers), and perhaps supported by one or more cruisers whose rôle would be to distract the defense by dazzling the gun layers with their searchlights and by fire action against guns and electric lights. But it is obvious that the addition of these vessels to the attack renders detection more likely and well-timed concerted action more difficult.

Essential Conditions for Defense

As the chance of success in the attack depends on surprise and dash, so successful defense will depend on organization, vigilance, good fire discipline and close cooperation between the electric light and artillery services; but nothing short of physical obstructions will give complete security. Exposed harbors must be protected by breakwaters, and the openings in these and the entrances to landlocked harbors must be closed by booms, which themselves must be protected by gun fire.

(i) *Gun Defense.*—The gun defense will consist mainly of light quick-firing guns which ought to be not less in number than the greatest probable number of torpedoboats likely to attack together, in order that every attacking boat may be engaged. Medium guns must also be provided to deal with boom smashers and cruisers.

(ii) *Electric Light.*—Depth of defense is important, and this depth is determined by the extent of water which the attack must cross that can be efficiently illuminated, and—when circumstances admit—by providing an outer zone of defense. The inner edge of the illuminated area should coincide with the boom, so that a vessel endeavoring to break through would be exposed to fire.

The strength of the attack will vary with the importance of the objective and the known or surmised strength of the defense. In any case several

boats would be employed, and in certain cases the number of boats employed might be 8 to 12.

For this reason it would be useless to employ defense lights for picking up and following individual boats. The bulk of the lights would be "fixed dispersed beams" spreading a fan of light over the channel. To give notice of approach an outer cordon of lights is necessary; these would be sentry and searchlights. One or more fighting lights would also be required to enable the medium guns to deal with cruisers and boom smashers.

Between the inner and outer cordons an intermediate installation of lights is often necessary to keep vessels which have passed the outer cordon under observation and hand them over, as it were, to the illuminated area.

Thus an ideal defense against torpedoboat raids would consist of:—(1) An outer defense armed with medium guns and provided with sentry, search and fighting lights, to deal with larger vessels or to break up and diminish the number of torpedoboat craft (it could not hope to sink them all) and to give warning to the inner defenses of an impending attack; (2) intermediate lights to keep boats under observation; (3) the inner defenses, consisting of the illuminated area and light anti-torpedoboat guns; and (4) lastly of the boom, one or more guns being specially told off to deal with any boat trying to get through. If there should be more than one channel of approach, then each channel should be guarded. In many places, however, the configuration of the shore will not admit of such depth of defense.

Conduct of the Anti-Torpedoboat Defense

An essential part of anti-torpedoboat defense is decentralization. The conditions of attack are such that each defense unit must act on its own initiative, and for torpedo craft the best unit is the single gun. For administrative purposes the unit may be a group of two or three guns, and the gun group commander would have the same duties and responsibilities as a battery commander of medium guns; but for tactical purposes the gun is the best unit, and the gun captain or gun group commander, if single gun groups are employed, must act on his own initiative. The passing of orders, once an action has commenced, would be almost impossible except to each gun separately. Constant readiness for action at night and in thick weather is necessary. Consequently the detachments must be divided into watches, enough men must be kept close to the guns ready to man them at a moment's notice, and a look-out sentry must be posted at each gun, which must be kept loaded, with an ample supply of ammunition ready to hand on the gun floor.

The duties of the sentry are to keep a sharp look-out seaward, and to open fire, without waiting for orders, on any torpedo craft moving at night; only if the gun group commander were actually present on the gun floor would he take his orders before firing. In case of the alarm being given by means of the alarm gong before a target had been sighted, the sentry would pass on the alarm to the detachment.

As any allotment of targets to the various groups and guns could not be made during the progress of an action, schemes of distribution of fire have to be drawn up in peace time, and frequently rehearsed; this will ensure every target being engaged. The units, as has been said, are independent as to command, but for communication purposes there is an intelligence center under an officer (rather miscalled the "fire commander" [F.C.]), who would transmit any warning he might receive from the outer defenses, or

from the special look-out posts, to the groups by ringing an electric alarm gong; the sentries would pass the alarm on to the watch on duty, who would take post on their guns; the watch off duty would be roused and would fall in ready to relieve or reinforce those on the guns. Directly a target appeared in the illuminated area, the action would commence without further orders, the guns concentrating on a single target or distributing on several, in accordance with the orders for distribution of fire, the main principles of which are, that no gun (unless specially reserved as a boom gun) should remain idle, that as far as possible every target should be engaged, and that once engaged on its allotted target the gun should stick to it till it is sunk.

The electric light services also require a careful organization to ensure continuous and efficient lighting; detachments must work in reliefs, and to allow for the inevitable interruptions due to the necessity of replacing carbons, etc., lights should always be mounted in pairs, so that one at least may always be burning. The electric light director has to carry out intelligently the orders of the responsible artillery officer for the movement of movable lights; and, where the fixed lights of the illuminated area are kept screened until the attack approaches, for the "dousing" and showing of the lights as ordered.

The daily routine of quick-firing gun detachments consists of a careful preparation for action every morning (night conditions may come on at any moment owing to fog), overhaul of electric firing circuits and ammunition, the testing of sights, replacement of ammunition if necessary, carrying out the necessary technical corrections to ensure accuracy of fire, and the posting of one sentry per group as a look-out. Telephone and alarm circuits must also be tested. An hour before dusk the preparation for action (which may have been omitted in the morning had there been no probability of fog) must in any case be gone through, the guns left loaded, trained, and layed for the point where the attack would first come under fire. The detachments would be divided into two reliefs, one sent below to rest, the other to remain in shelters on the gun floor but to keep awake. A sentry is posted on each gun as look-out, and part of his duty is to make the necessary sight asjustments for alteration in water-level due to tide.

DEFENSE AGAINST BOMBARDMENT

Bombardment of the dockyard or of the ships in dock or harbor does not appear to be a very likely form of attack. It is improbable, unless it could be delivered from a point out of range of the shore guns, and unless it were possible to observe the fire. It is unlikely, even then, on account of the large expenditure of ammunition and gun life entailed. But there are exceptions; for instance, when the capture of the town or place is the object of the attack, a bombardment in conjunction with a land attack might well occur (*e.g.*, bombardments of Gibraltar, Malta, Sevastopol, Port Arthur, Havana, etc., have occurred or are conceivable); and short of bombardment on a large scale, if a vessel out of range of, or outside the arcs of fire of the shore guns had a good chance of inflicting serious damage, or even of creating a scare, by long range fire, without an undue expenditure of ammunition, it might be attempted. Such bombardment can, of course, only be dealt with by the extended defense. The submarine is the best preventive. But in certain cases where the harbor is exposed and nearer to the attack than the guns protecting it, it may be advisable to mount high angle fire

guns with all-round arcs of fire to deal with this form of attack. Vertical fire against ships' decks is a form of attack they dread.

Bombardment from within range of the shore guns has little to distinguish it from direct attack, and would be dealt with in the same way; in fact, it could hardly be undertaken unless the shore guns had been silenced or were being heavily engaged by other ships.

DEFENSE AGAINST DELIBERATE ATTACK

It is doubtful whether the deliberate attack of one of our home coast fortresses would be undertaken by a Power at war with us. The silencing or destruction of the shore guns is not an end in itself, only a means to an end (that end being the destruction of ships and stores guarded by the guns), and if that end can be obtained at less risk and cost than that of vessels—costing about £2,000,000 each—and with less expenditure of ammunition and gun life difficult to replace, then other less costly means would be used. This does not mean that the heavy and medium guns of a fortress would never be engaged. A block-ship, boom smasher, or cruiser supporting a torpedoboat raid might often have to risk coming under fire of the shore guns; or a cruiser covering a landing attack might have to engage a fort to keep its fire from impeding the landing. Still less is this an argument for neglect or want of efficiency of the heavy gun armament. It is only if, and because, the armament is efficient and well served that the enemy's fleet will fight shy of coming under its fire.

The fire tactics of the shore guns would be the same in all these cases; their object is not so much to sink the enemy's ships as to keep them at a distance. Shore guns, as a rule, are not equal to sinking a modern battleship, or to silencing her guns; but their high explosive shell can, even at long range, inflict such secondary damage as would impair her fighting efficiency; and at long range the shore guns have great superiority in accuracy over the guns of a fleet, and have a more conspicuous target to aim at; whereas, at close range the ships could so smother the batteries with fire as to put them out of action for the time being. So that opening fire at the longest possible range, accurate and rapid ranging, well sustained fire once the range is found, and a suitable selection of projectile and point of attack, form the best tactics for the defense. At extreme range, however, it would often be difficult to select a particular point for attack; all that could be done would be to raise the point of impact after ranging on the water-line so as to bring fire to bear on the upper structures.

EXAMPLE OF DEFENSE AGAINST A DELIBERATE ATTACK

Warning of the Attack

The course of an action of the nature of deliberate attack might be imagined to be somewhat thus: During the night intelligence was received that a hostile squadron—strength, two battleships and an armored cruiser—had been seen at dusk about 120 miles east of the fortress steaming west. This intelligence is communicated to the fortress commander, by him to the section commanders, and on to the fire commanders and battery commanders. At 5:30 next morning, soon after dawn, a message is received at the Port War Signal Station from a station 20 miles to the east, that a squadron of the same number of ships, but unidentified, was approaching from the east and about 10 miles distant. This intelligence would be given to the "selected military officer," and by him communicated to the other fire commanders

and by fire commanders to their battery commanders, etc. Fire commanders would also report to their section commanders. Battery commanders would at once prepare for action, and make their calculations for corrections of range due to variable conditions of temperature, atmosphere, etc., for the range at which they expected to open fire and for two or three other ranges, and would break their men off when all preparations were complete. At about 7 A.M., say, the squadron would be sighted by the Port War Signal Station at a distance of 15,000 yards. Fire commanders would be informed and would order their battery commanders to sound the alarm; guns would be manned, and battery commanders would determine any final corrections for wind, etc.

If there was any doubt at the Port War Signal Station as to the squadron sighted being hostile, the "selected military officer" would be informed, and he would warn fire commanders not to open fire until the doubt had been cleared up, otherwise it would be the duty of fire commanders to open fire on their own responsibility. The Port War Signal Station would also give the "selected military officer" the name or class of any vessel identified. The identification of ships is a duty of a fire commander, but his training in this respect must necessarily be limited in comparison to that of a naval officer.

Allotment of Targets

The squadron would probably be within 14,000 yards when identified, and as it is all important that the ships should be engaged at the longest possible range, the fire commander's executive orders must be of the briefest nature and must be sent promptly, but they must give all the information required. A target must be allotted to each battery commander. This is done by means of "oriented" charts in fire commanders' and battery commanders' posts, and of a code which indicates to the battery commander the charted position of the ship he is to engage. In the case of a squadron, or more than one vessel, the relative position of the target ordered with regard to the other ships must also be given. To enable the battery commander to select the proper nature of projectile and best point of attack, the class of ship must be given. The ships of all nations being classified according to thickness and distribution of armor into a small number of classes, the battery commander, knowing the class, can by reference to his fighting book select the proper projectile and point of attack. Lastly, the battery commander should be informed whether any other battery commander will be engaging the target allotted to him. The whole of this information can be conveyed in a code message of eight words.

The ranging of separate works on to one target presents a difficulty which must be met by a well thought out scheme, frequently rehearsed in peace time and recorded so as to be available for all concerned. There are several different methods of overcoming this difficulty, and all have their advantages and drawbacks; the essential is to select one method and stick to it. To assist them in distinguishing the splashes of their own shell, battery commanders employ observers to note the flashes of their own and other guns: by timing the splash and knowing the range, they can generally say whether the splash is from their own battery or not.

Opening Fire

On receipt of the code message the battery commander would pick up

his allotted target and assure himself that he had chosen the one intended; he would point it out to his range-finders, flank observers, if any, and gun group commanders, and the latter would point it out to gun layers. The battery commander, consulting his target book, would order the projectile, and guns would then be loaded. He has still to ascertain the amount of correction in range and deflection which he must give for speed and direction of movement (this he ascertains by timing the ship's movement through a definite range and arc), and then, having determined the range at which he will engage, he can give his final correction and open fire. After having ranged on the water-line he would make any necessary corrections to raise his point of impact or alter it laterally, and can then proceed to "gun fire," which is the normal method for rapid sustained fire. He must continue to observe his fire, as with decrease of range, a change in correction will be necessary. As the vessel comes into closer range he would be able to employ any medium guns in his command with high explosive shell against the upper structures; and at closer ranges still he might be able to change to armor piercing shell with his heavy guns, with a view to silencing the enemy's heavy guns or to penetrating the belt.

The fire commander would watch developments and might have to concentrate fire on one ship or switch on to a new or unengaged target. As the range became shorter he could order into action any batteries of medium guns; if on a flank or well above his batteries, he would in many cases be able to assist battery commanders' observation of fire by being able to see over or to one side of the screen of smoke and spray which, hanging in front of the target, would often impede the battery commanders' observations.

It may be remarked that in this article the description of what would appear to be the most important function of coast defense—the meeting of a deliberate attack—occupies a very small space; the fact is that the best defense against attack is such perfection in organization, training and efficiency, that an attack would not be risked. It is an unfortunate fact that the more efficient the coast defense gunner is in the handling of his arm, the less likely is he to have an opportunity of using it, and the duties of the coast defense Royal Garrison Artillery in war time will consist much more in constant vigilance, in assisting to work the regulations for traffic smoothly and without delay, in occasionally firing a round at some ship disregarding these orders (probably from inadvertance or stupidity), than in an exciting action that would give them the opportunity of putting theory and peace training into practice.

Part III.—Future Developments of Coast Defense

I have not touched on the new arm, aviation, which bids fair to modify and alter the conditions of attack and defense of coast fortresses, because little is known of it from experience, and to speculate on its probable future uses and the best means of combating its offensive action would require a separate article.

As regards the future development of coast defense I think everything points to a development of the active rather than of the passive means of defense, and that it will come to be realized more and more that real security to dockyards, ships and stores protected by defenses can only be obtained by pushing out the line of defense farther in front of the establishments and

ships to be defended—and this in nine cases out of ten must mean an extended floating line of defense.

FACTORS THAT FAVOR THE ATTACKING FLEET

Recent increase in range and power of guns is more in favor of an attacking fleet than of the fixed defenses ashore, for several reasons. Firstly, it gives the attack a greater choice of positions from which to attack, not only because the area over which the attack can operate naturally increases with the length of range at which they can attack, but also because, when restricted to shorter ranges, ships would also in all probability be confined to certain channels, on account of shoals and banks lying near shore, and these channels—possibly narrow and intricate of navigation—could also be mined.

Thus a fleet armed with modern guns has a greater choice of positions; it could, for instance, take up an enfilading position from which perhaps only one gun of a shore battery could bear, and could more easily bring the concentrated fire of several ships on to one work.

This relative advantage of attack over defense would hold good even if the increase in power and range of the defense guns had kept pace with that of naval guns; but it never has and never will.

Again, the increased protection given to modern ships, and the possibilities of observation of fire conferred on them by the introduction of airships, very largely detracts from the advantage hitherto enjoyed by shore defenses of being less vulnerable and of possessing greater facilities for observation of fire than their adversaries.

Also the good effect of increased range in the gun is limited at night by the effective radius of illumination of electric lights, and may be limited by day by atmospheric conditions; and this neutralizes the advantages of long range guns to the defense in certain forms of attack, as, for instance, in the case of a mine-layer laying mines in a channel of approach beyond efficient electric light limit. Long range guns would be powerless to prevent this. Again, under cover of fog a ship or squadron might approach to within medium range; the defense would lose all the advantage of long range by being unable to attack during the approach, while at a medium range the greater number of guns probably carried by the attack would enable it to overwhelm and smother the defense. But great as has been the development of guns, the development of torpedoes in speed, range and accuracy has been as great if not greater. The advent and development of the submarine has done still more to increase the power of the torpedo as an offensive weapon, and on the whole this development of the torpedo is in favor of the defense.

GROWING IMPORTANCE OF TORPEDO AND ACTIVE DEFENSE

It would, therefore, seem probable that the future development of coast defense would lie in increasing the number and efficiency of defense flotillas of torpedoboats and submarines, rather than in the size and number of the guns on fixed mountings ashore. The gun cannot altogether disappear; there must always be a last entrenchment—a keep; and that keep will be the shore batteries.

But this development would at once give rise to the question whether the shore guns, which would then be merely the support of the main and more important part of the defense, should not be under the same command

as the extended defense, and whether the whole responsibility for defense against an attack from the sea should not rest with the Navy.

—*Army Review.*

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THE IMPORTANCE OF THE SUBMARINE

That Sir Percy Scott's letter published in the London *Times* of June 12th is not to be regarded as a bolt from the blue, appears from the two articles which we here present with his letter.

In the first of the two articles, taken from the *Journal of the Royal United Service Institution* for February, Brigadier-General F. G. Stone suggests the submarine as a substitute for coast batteries; while in the second, taken from *The Engineer* of April 3rd, the author, referring to the speech by the First Lord of the Admiralty in introducing the naval estimates, employs the word "anachronism" to convey to the reader the full significance of the First Lord's statements concerning the modern battleship.

It is true that, near the end of the second article, the author accepts as "fairly certain" that capital ships will continue to be the main naval arm; but, none the less, it is believed that the two articles are qualified heralds of Sir Percy's letter.

Sir Percy Scott's letter as here presented is taken from the *Army and Navy Register*.

—The Editor.

Submarines or Heavier Guns

By Brig.-General F. G. Stone

(Apropos of the Royal Artillery Prize Essay for 1913.)

"Great developments have recently taken place in (*a*) The heavy armament and armor of warships; (*b*) submarines; (*c*) aircraft. Consider how far this should justify alterations in the armament of our coast fortresses."

Such was the subject for the Duncan Prize Essay for 1913, and most interesting and instructive were the views of the numerous competitors for the coveted medal.

I propose to deal solely with (*a*) and the best means of attacking ships of the Dreadnought type, which should form the equipment of a modern coast fortress. The developments which have taken place recently in the heavy armament and armor of warships, were dealt with more or less fully by all the essay writers, some of them going into great detail and showing considerable technical knowledge; the majority of writers concentrated on the extent to which this development calls for heavier guns in the shore batteries, how much heavier than the existing 9.2 they should be, and the number and distribution of such heavier guns required by coast fortresses of various classes; there were also advocates for an increase in the number of high-angle batteries, and equally eloquent and persuasive advocates for the entire abolition of such batteries.

But there was a remarkable absence of any discussion on the merits of coastal submarines on the part of the writers; possibly some of them argued that the question on the tapis was—how far alterations in the *armament* were justified, and that submarines are not *armament*. But whether submarines are *armament* (for the purpose of the essay) or not, really does not affect the question; the point is that the existence of a submarine flotilla in any defended port, does most assuredly affect the question of the gun armament required to prevent hostile warships from placing the coast fortress at a disadvantage in a battle action.

Since reading the essays, I have gone very carefully into the relative cost of submarines and gun batteries, and find that the existing coastal submarines (C class) cost $\frac{1}{65}$ of the estimated cost of a 2-gun 13.5-inch

B.L. battery, and that the new coastal submarines are estimated to cost $1.\frac{1}{8}$ of the cost* of such a battery. In making this comparison, I have assumed acceptance of the view that one submarine attacking a warship may be regarded as not less effective than one 2-gun battery; and further, that at the extreme ranges of the gun, when penetration is at a minimum, and observation most difficult, the submarine is relatively more effective than the battery.

It is moreover obvious that the continuous improvement in the power and radius of action of seagoing submarines, must necessarily cause many less powerful craft to become regularly available for coastal defense, for which service they are admirably fitted; in such cases there will, strictly speaking, be no initial cost in the same sense as there is when a new means of attack or defense has to be provided for the specific service of a coast fortress.

There is a general consensus of opinion that our present coast armament is not sufficiently powerful to cope with the new conditions with which it is faced; and that greater offensive power in some shape or form is essential to enable coast fortresses to fulfil their rôle in the present day.

I think is has been sufficiently demonstrated that the cost of coastal submarines is much less than that of heavily-armed shore batteries; the cost of upkeep, manning and training of personnel is also somewhat less. Having therefore disposed of the financial question, it only remains to consider whether coastal submarines can actually and effectively supersede the rôle of shore batteries armed with a considerably heavier gun than the 9.2 B.L.

As regards material effect, there can be no question that the torpedo is mightier than the gun, *and the moral effect* of the known presence of submarines is paralysing. The submarine has a wider radius of action, but takes considerably longer to reach its objective than does the gun.

The organization of the coastal submarines for harbor defense in respect to what we in the R.G.A. term "Fire Control," must be dependent on the same system by which the selected military officer is enabled to inform fire commanders of the approach of a hostile or friendly warship; the exact procedure is, or should be, laid down by the naval authority in command of the port, and practised as a matter of routine, constantly during the year. It is not possible to deal more in detail with this subject, without trenching on confidential matters, but I hope that enough has been said to draw more attention to this branch of coast fortress defense, a close study of which will, I believe, convince others besides the writer of the Prize Essay, that the further development of offensive action by a fortress against a ship, beyond the power of the 9.2-inch gun, lies with the submarine and not with the heavier gun.—*Journal of the Royal United Service Institution.*

Warship Types of the Near Future

On various occasions during the last few months we have pointed out the fact that for the time being the strength of the attack as far as naval gunnery is concerned is out of all proportion to the capabilities of the resistance of modern systems of protecting ships, and in one or two cases have felt impelled to question the present value of armor for this purpose, in view of the altogether amazing disproportion between its cost of about £95 a

* This is exclusive of site value.

ton and the percentage of displacement—often amounting to 28 per cent of the whole ship—devoted to it, on the one hand, and the potentialities of accurate gun fire, on the other. These views were somewhat emphatically corroborated by the First Lord of the Admiralty in his speech introducing the Naval Estimates, when, in terms of distinct originality, he referred to a combat between modern battleships as by no means resembling "two men in armor striking one another with swords, so much as a battle between two eggshells striking one another with hammers." Improvements in guns, improved projectiles and gun sights, continual improvements in fire control have all contributed to advance the power of the attack; metallurgy has possibly—for the time being certainly—attained the maximum degree of resistance from metal of a given thickness. Mr. Churchill's statement, therefore, is to some extent a remarkable admission; his whole speech was interesting, but *the words quoted might almost be construed into a suggestion that the modern battleship in face of the 15-inch gun, the new torpedo, the submarine below and the seaplane above, was becoming an anachronism.** For long enough naval officers have been vexed as to what to do with battleships on the outbreak of a big war. For the same capital cost, either twenty big destroyers or one big super-Dreadnought can be provided; perhaps if it were not for the appalling cost of upkeep of the former as compared with that of the latter, the big ship programmes would have been halved and those of the small ship doubled. As it is, the number of destroyers, between 200 feet and 300 feet long, built and building for Great Britain and Germany, is approximately 500, and it is obvious that each country has in them a veritable hornets' nest which it could let loose about the battleships of the enemy.

For the moment, modern battelship design is trending in all countries very strongly to a standard arrangement of main armament. The details differ, it is true, and the practice of recent years has exhibited many variations; but the differences are more apparent than real. Five turrets, and still more so six, or even seven—as in the *Sultan Osman*, now completing at Elswick—have, perhaps, proved rather too many to carry on the center line of a ship between 500 feet and 550 feet long. For convenience of management in action it has become apparent in practice that about eight heavy guns on the broadside are about as many as can be comfortably handled. Coupled with this, there has been in this country a definite re-adoption of the 6-inch gun, not as a battle weapon, though as such it is available should circumstances permit, but as an anti-torpedoboat weapon. Foreign designers hardly ever abandoned this caliber, but that it was retained abroad for the former purpose quite as much as for the latter, has never been disputed. The latest arrangement, and one which seems likely to remain as much a standard all over the world as did the *Majestic* design, consists of four center line turrets, of which the inner pair fire over the two end turrets.

Between the two pairs, and arranged partly on the main and partly on the upper deck are the large anti-torpedo weapons distributed so that a large arc of training for ahead or astern fire can be obtained. With the increase in size of recent ships, these weapons can be placed so as to be practically unaffected by "blast," and at a sufficient height to be useful in a moderate sea—a condition which was never really fulfilled in the pre-Dreadnought ships, mainly on account of their small size. It is a remarkable fact that the general reversion to this design fulfils in every essential the

* The italics are the Editor's.

emphatically expressed views of the late Sir William White, who, towards the end of his career, always regarded the United States battleships *Michigan* and *South Carolina* as possessing a virtually ideal arrangement of armament. These vessels, which are of 16,000 tons and are practically identical in dimensions with the "King Edward" class, were laid down in 1906, though not completed till 1909. At the time of their inception, the system of superposed turrets was, for 12-inch twin mountings, a distinct novelty. Even at this period there was a considerable lack of unanimity in the ideas of naval officers regarding the number and position of the main armament. Four turrets simplified fire control; but some officers wanted more guns and the question of the triple turret arose. In the United States it is now generally adopted, but after the "Michigan" design had materialized it was at first thought better to carry five turrets; this arrangement was followed in the "Delaware" class, but six turrets were given to the *Wyoming*. An increase, however, in the caliber of the heavy guns from 12-inch to 14-inch enforced a return to five turrets in the *New York* and *Texas*, by which period the triple turret advocates had prevailed, and four center-line turrets are now the standard United States design. It is also the standard design for all battleships recently laid down in this country, and also for large battle-cruisers; in the latter, however, the after turrets are not superposed. This reduction in number of turrets has solved the very vexed problem that arose in the later British Dreadnoughts of where to put the anti-torpedoboat armament.

As regards types of British battleships, it was refreshing to hear from Mr. Churchill that the vessels to be laid down this year would contain one "Queen Elizabeth" class ship and three of the "Royal Sovereign" type, thus making, with the vessels of the 1912-13 and 1913-14 programmes, two homogeneous squadrons of six and eight vessels respectively. His tribute to British gun making was a well-deserved compliment to Sir W. G. Armstrong, Whitworth and Co. and to Vickers, Limited. Not only did the Admiralty take the important step of advancing from the 13.5-inch to the 15-inch, but, we are informed, this was done "without making a trial gun * * * and when the first 15-inch gun was tried just over a year ago, it proved to be the most accurate gun at all ranges that we have ever had." The somewhat emphatic praise that the First Lord lavished on this gun and on its general adoption for the vessels of the last two years' programmes is in rather distinct contrast to the silence of the official list in the Naval Estimates, wherein the caliber of the main weapons does not appear. But his striking comment on the "eggshell" features of the modern battleship, emphasized by the reference to the fact that the 15-inch gun can carry its high explosive charge at immense ranges through the thickest armor afloat, is less disturbing than his subsequent statement that "these facts suggest doubts as to whether the modern form of warfare between these enormous ships is not now approaching its culminating phase."

It is not unreasonable to assume that the superiority of the gun attack to the defense may bring about a temporary check to increase in dimensions even if questions of dock accommodation or initial cost of units do not do so, and it is more than probable that the next few years will witness a similar adherence to the same dimensions, displacements or armaments that characterized the period immediately subsequent to the "Majestic" design.

But gun fire alone is not now the only check to increase of size. If the destroyer and the submarine may not yet be regarded as also superior in

attack to the defense, there is no doubt that they may become so at no distant date. True, neither is yet a sea-keeping vessel, but the larger modern destroyers have long been more like small cruisers than torpedo craft. The conditions surrounding the design of all these light, fast craft—whether cruisers or destroyers, as well as those affecting the below-water boats—are in a state of flux at the present time to an extent to which it is difficult to recall a parallel.

That the type of destroyer we have recently laid down is doomed to undergo considerable change in future programmes there is little doubt. As we have already suggested, this is likely to take the form of boats of rather smaller size, but higher speed, with much more powerful torpedo armament, and led possibly by one or two flotilla leaders of greater size, speed and gun power. Mr. Churchill stated that the true destroyer of torpedo craft for work in the North Sea is the light cruiser of the "Aurora" type, but be rather qualified this by saying that the cruiser design for the coming year is still under consideration, and a further statement will be made about the design in July, when the discussion on the shipbuilding vote takes place. The fact is that the rapid development in technical progress, especially as regards the air and submarine services, is rendering the question of the most suitable type of warship a particularly difficult problem. *What, for instance, is going to be the position of the submarine in five years' time?** It can hardly be doubted that it will have been evolved into something of the dimensions of a light cruiser of the present day, but with submersible qualities. There are already in existence submarines of about 1000 tons displacement, carrying ten torpedo tubes, with surface speeds approaching 20 knots, and an advance from these to a submersible cruiser is surely no greater step than that which was taken on a large scale when the last "River" class designs were shelved in favor of the "Tribal" type. A new duty for submarines may be the laying of mines. The very presence of a vessel on a certain course may lead to the belief that she is a mine-layer, and that locality will be avoided or swept, but a submarine mine-layer would do her deadly work unseen.

No one who studied the designs recently exhibited at Olympia can doubt the effect that aeroplanes must have on future operations both on land and sea. The chain of seaplane bases round the coast is being gradually extended, and it is inevitable that much of the work recently performed by the destroyer patrolling flotillas will in time be transferred to the air service. The development of the seaplane into a standard type for war purposes is proceeding rapidly, the two main designs being the scouting type, and the heavier form for carrying explosives. The aeroplane proper—that is to say, without the somewhat cumbrous floats—is essentially a land type, but as a fighting instrument is obviously the more efficient, as it can carry heavier weights of explosive and is far more easy to maneuver. Either type, however, can cross the North Sea and return comfortably in the course of a day. The influence of the speed of aeroplanes upon contemporary warship tactics is liable to be truly enormous.

It would seem, therefore, that some of the main duties of both light cruisers and destroyers are trenched on by the greater facilities for undertaking them possessed by the seaplane. What, then, is to be the *rôle* which these vessels are to play? The existence afloat of a capital ship of, say, 30,000 tons and 25 knots speed, costing £3,000,000, must inevitably be a

* The italics are the Editor's.

tempting bait if a lucky attack by a couple of boats, costing together less than 10 per cent of the large ship, can destroy or so damage it that for all practical purposes it can be neglected as a fighting unit. It is to guard against this that the "Aurora" class presumably has been designed, but *the question of how the "Auroras" can tackle the submarine, or, rather, submersible torpedoboat, has not yet been solved.** Even if it be assumed that such craft can be seen in daylight from airships—which has not been proved—it may quite likely be found impossible to damage them, owing to the escort of attendant cruisers armed with high-velocity rapid-fire anti-aeroplane guns, the development of which has long been a foregone conclusion.

Primarily, it would seem that the influence of submarine and airship on naval design would be to force an all-round increase of speed, though such as can reasonably be obtained in any class of ship is but small compared with that of the aerial vessel. For the time being, the development of the big gun may also be believed to have reached high-water mark in view of its exceptional power at ranges almost beyond those of telescopic sights or range-finders. That capital ships will continue to be the main arm of any navy, except those of minor Powers with few or no interests beyond their own internal affairs, is also fairly certain. But the design of cruisers and destroyers seems, as we said above, to be in a state of flux from which it is difficult to see the outcome. For far distant services the present type of cruiser or destroyer may well suffice for many years; but for home services, save when the elements are in such disorder that neither seaplane nor submersible dare venture out—and herein lies the greatest claim to survival of existing warship designs—ships afloat on the surface of the sea are a *sine qua non*.—*The Engineer.*

Submarines or Dreadnoughts

To the Editor of the Times

Sir:

Although I have retired from his majesty's navy, many people have written, and are still writing, to me as to whether we should build small battleships or large. My opinion is that we should not be building either. My reasons for holding this opinion will be found in a letter I wrote some time ago, and a copy of which I enclose herewith.

I am yours, truly,

Percy Scott.

52 S. Audley Street, May 31.

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52 S. Audley Street, Grosvenor Square, W.

15th December, 1913.

Dear Sir:

In reply to your letter I have seen the correspondence in the Press suggesting building smaller battleships and also the arguments as to whether two or four battleships should be laid down in 1914.

If we have battleships we must have thick armor on them to keep out the enemy's shot, and we must have speed to give a tactical advantage in bringing our fire on the enemy; these are axioms among naval officers. For

* The italics are the Editor's.

battleships our nation and all other nations have very properly decided to have big ships, big guns, thick armor, and high speed.

The other question is, Are we in 1914 to build two or four battleships? The little navyites say two in order to save money; the big navyites say four to, as they think, save the country. If battleships are of use in saving the country, the little navyites are foolish and unpatriotic. If battleships are of no use, then the big navyites are wrong in putting the country to the expense of building four more; the real question to settle before even talking about building more battleships is, Are they of use or are they not? For some thousands of years armed vessels floating on the surface of the water have been used for attack and defense; these vessels today vary in size from a canoe containing one man armed with a spear to a 32,000-ton battleship armed with 15-inch guns, and these craft, whether large or small, all float on the water and are visible. In this island we depend upon our food supply coming from over seas; hence it has been necessary for us to have a large number of armed ships to protect our commerce and to safeguard our food supply. This protecting force or insurance of our country is called the royal navy and today consists of a large number of ships that swim on the water and can be seen and a few that swim under the water and can not be seen.

The introduction of the vessels that swim under water has, in my opinion, entirely done away with the utility of the ships that swim on the top of the water.

The functions of a vessel of war were:

Defensively:

1. To attack ships that come to bombard our ports.
2. To attack ships that come to blockade us.
3. To attack ships convoying a landing party.
4. To attack the enemy's fleet.
5. To attack ships interfering with our commerce.

Offensively:

1. To bombard an enemy's ports.
2. To blockade an enemy.
3. To convoy a landing party.
4. To attack the enemy's fleet.
5. To attack the enemy's commerce.

The submarine renders 1, 2, and 3 impossible, as no man-of-war will dare to come even within sight of a coast that is adequately protected by submarines; therefore, the functions of a battleship as regards 1, 2, and 3, both defensively and offensively, have disappeared.

The fourth function of a battleship is to attack an enemy's fleet, but there will be no fleet to attack, as it will not be safe for a fleet to put to sea. This has been demonstrated in all recent maneuvers, both at home and abroad where submarines have been employed, and the demonstration should have made us realize that, now that submarines have come in, battleships are of no use either for defensive or offensive purposes, and consequently building any more in 1914 will be a misuse of money subscribed by the citizens for the defense of the empire.

As regards the protection of our commerce on the high seas we must examine who can interfere with it.

Turkey, Greece, Austria, and Italy must pass through the narrow Straits of Gibraltar to get at our commerce.

Cyprus, Malta and Gibraltar, well equipped with aeroplanes to observe the enemy's movements and submarines to attack him, would make egress from the Mediterranean very difficult.

Spain and Portugal have ports open to the Atlantic and could interfere with our commerce, but war with those countries seems very improbable, and they are not very far from Gibraltar.

France from Brest could harass our commerce, but if homeward-bound ships gave that port a wide berth and signaled by wireless if they were attacked, fast cruisers and submarines from Plymouth could be very soon on the spot.

Russia and Germany are very badly placed for interfering with our commerce; to get to the Atlantic they must either run the gantlet of the Channel or pass to the north of Scotland, and even if they get out they have nowhere to coal.

America could attack our commerce, but they would have a long way to come.

If by submarines we close egress from the North Sea and Mediterranean, it is difficult to see how our commerce can be much interfered with.

It has been suggested to me that submarines and aeroplanes could not stop egress from the Mediterranean; that a fleet would steam through at night. With aeroplanes that would report the approach of a fleet and thirty or forty invisible submarines in the narrow Strait of Gibraltar, trying to pass through them at night would be a very risky operation.

Submarines and aeroplanes have entirely revolutionized naval warfare; no fleet can hide itself from the aeroplane, and the submarine can deliver a deadly attack even in broad daylight.

Under these circumstances I can see no use for battleships and very little chance of much employment for fast cruisers. The navy will be entirely changed; naval officers will no longer live on the sea, but either above it or under it, and the strain on their system and nerves will be so great that a very lengthy period of service will not be advisable; it will be a navy of youth, for we shall require nothing but boldness and daring.

In war time the scouting aeroplanes will always be high above on the lookout and the submarines in constant readiness, as are the engines at a fire station. If an enemy is sighted, the gong sounds, and the leash of a flotilla of submarines will be slipped. Whether it be night or day, fine or rough, they must go out to search for their quarry; if they find her, she is doomed, and they give no quarter; they can not board her and take her as a prize, as in the olden days; they only wait till she sinks, then return home without even knowing the number of human beings that they have sent to the bottom of the ocean.

Will any battleship expose herself to such a dead certainty of destruction? I say, No.

Not only is the open sea unsafe; a battleship is not immune from attack even in a closed harbor, for the so-called protecting boom at the entrance can easily be blown up. With a flotilla of submarines commanded by dashing young officers, of whom we have plenty, I would undertake to get through any boom into any harbor and sink or materially damage all the ships in that harbor.

If a battleship is not safe either on the high seas or in harbor, what is the use of a battleship?

It has been argued to me that if a foreign power destroys our submarines we are at the mercy of his dreadnoughts. There can be no doubt about the accuracy of this statement, but submarines are difficult to destroy, because it is difficult to attack what you can not see. A power that sends out ships to look for and destroy submarines will be courting disaster; the submarine when in the water must be kept away from, not looked for.

Submarines will be hauled up on land, with arrangements for instantly launching them when required; they can only be attacked by airships dropping bombs on them.

What we require is an enormous fleet of submarines, airships and aeroplanes, and a few fast cruisers, provided we can find a place to keep them in safety during wartime.

It has been argued to me that our enemy will seize some island in the Atlantic, get some fast cruisers there, with plenty of coal, and from this island prey on our commerce. This is ridiculous; the moment we hear of it we send a flotilla of submarines towed by an Atlantic liner, she drops them just when in sight of the island, and she brings them back to England when they have sunk everything they found at the island.

If we go to war with a country that is within the striking distance of submarines, I am of opinion that that country will at once lock up their dreadnoughts in some safe harbor; we shall do the same; their aeroplanes and airships will fly over our country; they will know exactly where our ships are, and their submarines will come over and destroy anything and everything that they can get at.

We shall, of course, do the same; but an island with many harbors and much shipping is at a great disadvantage if the enemy has submarines.

I do not think that the importance of submarines has been fully recognized; neither do I think that it has been realized how completely their advent has revolutionized naval warfare. In my opinion, as the motor vehicle has driven the horse from the road so has the submarine driven the battleship from the seas.

I am yours, truly,

PERCY SCOTT.

—*Army and Navy Register.*

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GUNS AND ARMOR

The summer meeting of the German Naval Architects was opened on May 27th in Stuttgart in the presence of the King of Würtemberg in the hall of the National Museum. After speeches of welcome had been delivered by representatives of the Government and of the town of Stuttgart and by the Rektor of the Technical College, Geheimrat Professor J. Rudloff, of Berlin, read a paper on guns and armor.

Observing that the contest between guns and armor had again become keener, the author said that it really dated from the introduction of the shell in about 1820, but that it had taken a more pronounced form thirty-three years later after the decisive results of the battle of Sinope, when the Turkish and Egyptian flotilla was destroyed in a very few hours by the Russians. Guns of 45 tons weight were built in the early seventies. The *Duilio*, the

Gloire, and the *Inflexible*, the latter with very thick armor, represented the earlier steps in the development. After the *Inflexible* armor, had come the Schneider, the "compound," the nickel steel, the Harvey and the Krupp armors, the last-mentioned having a resistance 2½ times as great as that of the old wrought iron plates. Modern armor plates of 350 mm. (13.8 inches) in thickness had greater power of resistance than the 610 mm. (24 inches) *Inflexible* armor. Improvements in the design, material and proportions of the gun tubes and the use of better powder had, even for considerably smaller calibers, led to better performances than those of the 45-ton guns. Meanwhile the projectiles had begun to be made of case-hardened wrought steel; their lengths were increased, and they were provided with caps. The 30.5-cm. (12-inch) gun was introduced in the middle of the nineties, since which time until quite recently it had held its ground. The power of the 30.5-cm. gun had in Germany been gradually increased, but not in Great Britain. This latter circumstance was attributed by the author to the fact that the British wire-wound construction would not allow of a further increase of pressure; he also stated that, in spite of improvements, the life duration of the wire-wound guns was still unsatisfactory. The increase to 34.3 cm. (13½ inch) had been made partly on this account and partly to enable greater bursting charges to be given; it was not intended to give increased penetration, which, for the 230 mm. (9-inch) armor plates to be pierced, was already sufficient. The advent of the *Dreadnought* brought armor up to 279 mm. (11 inch), and later up to 350 mm. (13.8 inch), though even here the penetration of the improved 30.5-cm. gun was still sufficient at the fighting distances formerly contemplated. Meanwhile, however, the power of the torpedo had been greatly increased, and it was anticipated that the naval battles of the future would be fought at greater distances. Although the more lightly armored parts of the vessels could still be pierced by the 30.5-cm. guns, it was desirable to have larger guns to pierce the water-line and other thicker armor, and consequently the newer vessels had been designed with guns of 35.6 cm. (14-inch) and even 38 cm. (15-inch) caliber. As regarded the life of the gun, the author said it was necessary to work with reduced charges in time of peace. He gave some illustrations from British practice, and a formula for the life of the gun taken from *The Engineer*, 1911, Vol. I., page 399, but avoided giving a comparison between British and German conditions. Tabulated results adduced for some larger and smaller guns showed that a 6-inch gun could fire about five times as many shots as a 12-inch and about 6½ times as many as a 13½-inch gun. Amongst other advantages of the large gun was the increased bursting charge which it made possible in A. P. projectiles, which came nearer and nearer to that of the explosive shell. This suggested the possibility of having one type of projectile on a vessel instead of two. Turning to the *Dreadnought* and her successors, the author noted with satisfaction that the all-big-gun system was being given up again in favor of that of a combination of larger and smaller guns, which Germany had never abandoned. With regard to the 30.5-cm. gun, it was desirable, in view of the practical advantages of uniformity, to keep it as long as possible, but the advantages of the 38-cm. gun were so great that its adoption was to be looked for. The gun arrangement on shipboard would be simplified by the introduction of this weapon in so far that it would no longer be necessary to put three or four guns in a turret, as had been done in America and in France. The author finally suggested

that, since the number of the German war vessels was fixed by law, it was desirable to increase the fighting value of the individual units.

Geheimrat Professor Hüllmann, who rose to discuss the paper, gave expression to the view recently held in English circles that fire superiority was the one factor of importance, as was shown by the naval battles of the past, and said that this was therefore in all cases to be aimed at. Moreover, in addition to the material damage, the moral effects of the blow of a projectile of about a ton in weight and having 400 m. striking velocity must not be left out of account. A further argument for the use of large calibers was the behavior of the projectiles in striking the water, the larger sizes showing less tendency to ricochet than the smaller ones. He was sorry that careful firing trials with the 38-cm. gun were not yet available.

—*The Engineer.*

THE MANUFACTURE OF ARMOR PLATE

With the advent of iron-clad vessels for use in naval warfare arose the question of armor. The old *Monitor* and *Merrimac* are the first examples of this type of vessel, but with the improvements in gun manufacture, it became apparent that the wrought iron plates as first used, could not withstand heavy gun fire. As a result a *compound armor* plate was developed in England and an *all steel* plate in France. However, in 1889, nickel was introduced in steel and a plate of great toughness and resistance was produced. This type of armor proved superior to the old and from then, onward, the march of progress has increased. In 1890 the Harvey process was advanced and met with great success, followed in 1895 by the Krupp process.

These two processes are essentially the same in principle and represent the highest development of the compound type of armor.

Formerly, this kind of armor was manufactured by taking a wrought iron plate as a backing and casting upon its face a plate of steel, the former being so heated as to produce as perfect a union as possible. This operation was based on the theory that a plate to resist the powerful energy of a projectile must have a hard face to resist penetration and a tough back to prevent shattering on impact. Difficulty, however, was experienced with the flaking of the steel face, so that the homogeneous nickel-steel plate really superseded this type, until the Harvey plate was adopted.

This process was really a step backward; in principle it was based on the compound type, but was its perfection. The Harvey plate was produced by the application of the *cementation* process to homogeneous steel plates. The Krupp process is the same, but owing to a different composition of the steel used, it is susceptible to a greater treatment which improves its ballistic resistance.

The manufacture of a Krupp armor plate consists of a series of distinct operations requiring great care and attention and covers a period of from four to nine months, depending on the thickness of the plate.

The composition of the plate having been determined upon, the necessary elements are melted together in an open hearth furnace. When ready for tapping, the ingot mould having been prepared, the metal is run into a large ladle, from which it is poured into the mould through a gate on the outside which connects with the interior of the mould at the bottom. The

ingot is bottom poured so as to get a more perfect ingot and the large projection on the upper end, the sink-head, is an aid in handling. The mould is made up of cast iron sections bolted together to facilitate the stripping of the ingot * * * * .

After the ingot has cooled, it is stripped, that is, it is removed from the mould. Usually twenty-four hours suffice for the ingot to solidify and cool sufficiently to permit its being stripped, and then the ingot is sent to the heating furnaces preparatory to forging. The ingot after being heated for about twenty-four hours is taken out of the furnace and receives its first forging. This operation is one of the most wonderful sights in a steel plant: to see a red hot mass of metal weighing in the neighborhood of 80 tons, being handled entirely by mechanical means with the ease that one would handle a pencil. The ingot is placed on a die under a 14,500 ton hydraulic press and there forged to within a few inches of its finished thickness. At each working of the press the metal is decreased about three inches in thickness, the ingot being moved along until its whole length has been forged. Of course, the length and breadth are increased, the metal under such great pressure flowing evenly in all directions, and this operation is repeated until the required dimensions are obtained.

It has been the practice of some manufacturers of armor plate both in this country and abroad to use a series of rolls instead of a press, but it has been proven that the forging of a plate under a hydraulic press effects a more uniform working of the metal and produces a finished plate far superior to one which has been rolled. This statement is borne out by the fact that many of the plants which had installed a costly set of rolls, have had the same removed and replaced by powerful hydraulic presses.

After forging, the sink-head is cut off and the plate allowed to cool a little in air before annealing. Of course, it is readily understood that actual degrees of heat and time of treatments cannot be entered into in any detail, as these various processes are manufacturers' secrets and are carefully guarded.

From the annealing furnace the plate is taken to be scaled by pneumatic hammers preparatory to carbonizing. This process is that known as the *cementation* process and consists essentially of heating the plate in the presence of dry carbon or in a gas-carbonizing furnace.

In the dry-carbon process a special dry-carbon furnace is employed; coal is used in the furnace as fuel and the flame passes over the plates, down in front and back under again to the smoke-stack. Usually several plates are carbonized at the same time, the plates being arranged in pairs. The faces to be carbonized are placed together, separated only by a layer of finely powdered wood and animal charcoal. The edges are well sealed and the plates are placed in the furnace through the top and lowered on a bed of sand; the whole is then well covered with sand and if more than one pair are carbonized at the same time, they are treated in like manner and placed on top of the first. When all are well protected from contact with the flame, the furnace top is closed and the furnace brought up to heat. The heat is maintained at a uniform temperature for a considerable length of time, this time depending on the amount of carbon to be absorbed by the plates, and then the furnace allowed to cool. Almost a month is employed in this process, from the time the plate is charged until it is taken from the furnace.

If the gas-carbonizing process is employed, the plate, with the face to be carbonized exposed, is placed on a bed of sand in a furnace which is heated

by some highly carbonized gas. The flues for the flame entry are built on each side of the furnace and so arranged that they can be used alternately, while a deflector causes the flame to first strike the top of the furnace and then pass downward. After the furnace has been raised to heat, coal gas or one rich in hydrocarbons, is passed along the surface of the plate and the intense heat causes this to be broken up, depositing carbon on the face of the plate. The plate is left in the furnace until the required degree of carbonization is attained.

The plate is then again scaled and reheated for its second or final forging to bring it to gauge. This forging also serves to smooth up any roughness on the surface. After forging it is again annealed and from the annealing furnace goes to the machine shop, for such machining as can be done preparatory to bending.

On return from the machine shop, the plate is heated preparatory to bending and this operation requires the greatest skill and experience in order to prevent cracking to a degree which would result in the condemnation of the plate. An allowance, too, must be made for any slight distortion which may occur in the next operation, that of tempering and water hardening.

The plate is heated to the required temperature and then subjected to a cold water spray. The bath is of a special design and is arranged to give a pressure of about fifteen pounds per square inch.

The plate is then ready for the inspector. He takes a number of high grade punches and goes carefully over the whole carbonized face, testing every square foot for hardness. The punch must be dulled and the surface of the plate show practically no mark. If this test is satisfactory, the *coupon*, which has been previously cut in the machine shop is broken off to show the structure of the plate by its fracture. Then follows the drill test to show the depth of chill and if the plate passes this test, bars are taken to show its physical characteristics, that is, tensile strength, elastic limit and extension.

After the above tests are completed, the ballistic plate is picked—that is, a plate to be fired at and which represents a group of plates. The armor for a battleship is divided into groups of from 400 to 600 tons, as determined by the Department. This test is the most important and on its acceptance or rejection hangs the fate of the whole group of armor; as a result the inspector usually picks that plate of a group, which in his opinion is the least likely to pass. Of course he has a record of all the plates, and going over these most carefully, he chooses the one which for some little reason or other, is not as perfect as the others, assuming that if the plate in question can pass the severe test required of it, the other plates of the group most assuredly can.

The plate having been decided on, it is sent to the Proving Ground for test. Here it is attached to a structure, braced from the rear and bolted in the same manner as armor on shipboard. When in readiness, three shots are fired at it, the actual thickness of the plate determining the gun to be used and the initial velocity. Approximately a gun of the same caliber in inches as the armor in thickness is used and no projectile or fragment thereof shall get entirely through the plate, nor shall any through crack develop to an edge of the plate or to another impact.

The plate having successfully passed test, the group is accepted and the remaining plates are finished machined; of course a replacing plate is substituted for the ballistic one.

After the plates are finished machined, prior to shipment, they are erected in the shop to insure accuracy of design and continuity of joints, so that they can at once be attached to the ship's structure on arrival at destination.—*The Navy.*

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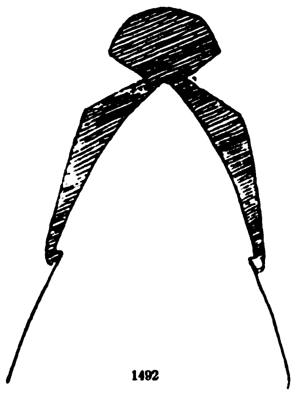
THE NEW HADFIELD CAP

The new Hadfield cap for A. P. shell is shown in the sketch. It is claimed that it facilitates penetration without breaking up, especially on oblique impact. British Patent 21,903 of 1-10-13.



—*The Journal of the Royal Artillery.*

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NORWEGIAN COAST DEFENSE SHIPS

The two latest ships, like their predecessors, are of a type which is rarely constructed in this country, but which, nevertheless, is found to be of great service for the defense of the coast of Norway. They are relatively small, but carry an effective armament for their size. The two coast-defense armor-clads built in 1897 were of 3450 tons displacement, and mounted two 8.24-inch and six 4.7-inch guns. These two vessels were succeeded by a pair of slightly larger vessels in 1900, the displacement being 3847 tons and the armament two 8.24-inch guns, in addition to six 6-inch weapons instead of the 4.7-inch guns in the preceding ship. The two vessels now being built, the *Nidaros* and *Biorgvin*, are of 4825 tons displacement, and in their case the armament consists of two 9.45-inch guns, four 6-inch and six 4-inch guns, all of 50 calibers in length. Apart from the increase in the bore of the guns, there has been a great advance in their energy. Thus the 8-inch gun of 1897 had a muzzle energy of about 10,600 foot-tons, whereas the 9.4-inch gun now fitted has a muzzle energy of over 20,000 foot-tons. The 9.4-inch guns in the later ships are mounted in pairs, two in an armored gun-house forward and two in a corresponding position aft, while the 6-inch guns are singly mounted within a citadel. Machine and landing guns are also carried, and the vessel is fitted with two submerged tubes for discharging 18-inch torpedoes. The new vessels have a length of 210 feet over all, and

of 290 feet between perpendiculars, the breadth (moulded) being 75 feet, and the depth 26 feet; the draught in service is 26 feet 6 inches. The earlier ships were fitted with reciprocating engines, whereas the new ships will have turbine machinery. The manufacturers of the machinery for all six ships have been Messrs. Hawthorn, Leslie and Co. The designed speed is 15 knots, which corresponds with that of the earlier four ships, so that these six ships, forming the main squadron of the Norwegian protective navy, have a uniform speed. The new ships are protected by a water-line armor belt of 7 inches in thickness, tapering to 4 inches at the ends, while the barbettes for the 9.4-inch guns are of 8-inch armor. The citadel in which the 6-inch guns are located is of 4-inch armor, and is above the main belt. There is also deck protection of 2 inches thickness. It will be recognized, therefore, that the two ships, which are well advanced (all the boilers and funnels being in position before the launch), will constitute very efficient weapons for the money expended upon them.—*Engineering.*

EXTRACTS FROM THE BIMONTHLY ORDNANCE REPORT FOR MAY-JUNE, 1914

THE ORDNANCE BOARD

Compressed high explosive bursting charges in papier-maché cartons.—Satisfactory, except occasional difficulty in fitting, due to irregular dimensions of cavity. Fragmentation tests excellent.

Effect of steel disc attached to ogive of projectiles for 4.7-inch field gun.—Results of firings indicate that increase in angle of fall is sufficient for effective curved fire at ordinary ranges.

Hook for new design of portable lamp on gun carriages.—Satisfactory.

FRANKFORD ARSENAL

Hand fuse setters, model of 1913.—An order has been received for the manufacture of fifteen hand-fuse setters, model of 1913, for 5-inch siege gun, and twenty-one hand fuse setters, model of 1913, for 7-inch siege howitzer. The ammunition with which these fuse setters is used is fitted with 45-second fuses.

Whistler-Hearn plotting board, model of 1904.—Gun arm locking screws are being manufactured for issue for all Whistler-Hearn plotting boards, model of 1904, in the hands of the regular service.

Drill projectiles for 4.7-inch howitzer.—The type drill projectile for 4.7-inch howitzer has been tested at Sandy Hook Proving Ground, and the design approved. Work on the manufacture of 144 drill projectiles has been resumed.

ROCK ISLAND ARSENAL

Canteens and cups, model of 1910.—The plant for the manufacture of canteens and cups, model of 1910, has been completed, and the manufacture of these articles is now under way.

Canteen covers, model of 1910, mounted.—These canteen covers are no longer to be manufactured as these articles are to be carried in the saddlebag.

Hardware.—Corrosion tests on samples of Bentempi and Eberide iron

and steel finished hardware to determine whether these finishes are superior to that now in use at this arsenal are now in progress.

SPRINGFIELD ARMORY

Test of boxes containing service ammunition, in a jolting machine.—This test was conducted in an improvised jolting machine built to hold two ammunition boxes rigidly, which were subjected to two severe vertical shocks and two severe horizontal shocks for each revolution of the machine, the object being to determine whether the method of carrying the ammunition in the boxes is satisfactory.

Test was made of 300 rounds of regular ammunition and 300 rounds of re-loaded ammunition, the machine being run 6 hours, or about 90,000 revolutions (360,000 shocks). At the end of the test the ammunition was examined and found to be in good condition, and upon firing the cartridges they functioned satisfactorily.

WATERVLIET ARSENAL

4.7-inch howitzers, model of 1912.—Sixteen manufactured.

Short Notes

Are Larger Naval Guns Necessary?—If and when the question of mounting still heavier guns on British battleships is put forward by the gun manufacturers of this country—as will probably be the case at an early date—the gunnery expert and the naval architect are likely to have something very cogent to say on the matter. Our 15-inch gun is at present as large a gun as we need—so the constructor and gunnery expert argue—because it will easily penetrate the thickest belt of armor on any battleship afloat, or likely to be in the fighting line for many years to come, and because it is undesirable to carry the turrets higher than they are carried at present—a maximum of about 30 feet. To mount primary guns higher than this above the waterline is to unduly expose them as targets to an enemy, and questions affecting the stability of the ship are raised in an acute form. Besides, the present height gives a dim horizon at 12,000 yards, and the angle of descent is so rapid at this distance that the inclination of the axis of the shell to its trajectory, with its powerful crossbreaking effect on the projectile, makes a longer range almost prohibitive, and direct hits would be exceedingly difficult to obtain, even at 12,000 yards. If primary guns could be carried at the same elevation as the fire-control apparatus, then longer-range guns might be desirable, but according to the authorities quoted above the limit has been reached, for the moment, at any rate, and is more likely to recede than advance if no improvements are made in the manufacture of armor.

—*United Service Gazette.*

French Views on Armor Protection.—The prospective expansion of the shipbuilding programme has brought to actuality the question of armor protection. Criticism is offered to the decision of the Admiralty to adopt belts of only moderate thickness at a time when the ever-increasing caliber of heavy guns impels England and Germany to much strengthen the protec-

tion of the water-line. Within the last eight years the progression has been in France from 10 to 12 inches, whereas the thickness of belts has passed in England from 10 to 13.5 inches, and in Germany from 12 to 15 inches. Even the fine *Normandies* are outclassed, in the matter of armor belts, by the British *Warspites* and the German *Kœnigs* and *Wœrths*. To such reproaches constructional experts answer that the maximum thickness of the belts is no criterion as to the real value of the protection of a given ship, a *Majestic*, for instance, with a relatively thin, but very broad water-line armor, being better protected than a *Carnot*, the 17-inch belt of which is submerged at sea. Not only are the *Barts*, *Bretagnes*, and *Normandies* a great improvement on their predecessors, but their defensive designs embody the data of the *Iéna* experiments, and, all points considered, well satisfy battle requirements. The fitting amidships of plates of very great thickness, imperviable to the most powerful guns, would entail either a substantial increase in the displacement and cost, a suppression of armor on ends, as in the British and American super-dreadnoughts, or the reduction of its thickness to some 4-inch, as in the ships of the Triple Alliance; all courses not commending themselves to the bulk of French naval men, who prefer more guns rather than additional armor.

—*Proceedings of the United States Naval Institute.*

Development of the Battle Cruiser.—The development of the battle cruiser has been little short of marvelous since this type of vessel was first introduced to the world by the British Admiralty. Its effect on naval strategy will probably never be fully measured or realized, until the first great naval war between modern fleets has taken place. What may be described as a race, so far as naval regulations permit anything of that kind, took place between our own battle cruisers in the Channel a few weeks back, and the winner, the *Queen Mary*, worked up to a speed of 34 knots the hour as a maximum. For an admiral to possess a "flying squadron" of four or six such speedy capital ships as this, armed with eight of the most powerful guns afloat, is for him to possess a rapidly moving force calculated to upset the plans of a remote enemy in a way never possible in the past, and, perhaps, little looked for in the present. The speed of 34 knots is one expected in a top-line destroyer, rather than in what used to be considered a lumbering capital ship; and this speed in a battle cruiser will not only modify naval strategy, but also the tactics of torpedo craft in all but hazy or foggy weather, for no enemy's destroyer so far built would be able to escape from the *Queen Mary* even in smooth weather on the open high seas; an attack on a battle fleet will have to be conducted in a very different way, and at much greater hazard, than was the case before the battle cruiser made her appearance.

—*United Service Gazette.*

Problem of the Turret in the United States.—The battleships which will next be built will correspond in all essential particulars to No. 39. Some consideration has been given to changes in the chief characteristics, but, in general, there will be no radical departure from the type represented by No. 39. This adherence to design includes armor and armament, although in the former particular it is possible there will be an increase in certain parts, notably as a protection against under-water attack. The 14-inch gun is destined to be retained, despite the foreign inclination to favor the 15-inch gun. There

will also be a retention of the triple-gun turret, although that form of mounting the main battery is yet to be practically tested. The fact that the French are contemplating the installation of the quadruple turret in the "Tourville" class is not influencing in that direction the American ordnance officers. There are advantages in the triple-gun turret, for the reason that the three guns may be fired at once. The quadruple turret is a step backward in some respects, since the quadruple turret is simply a twin turret placed side by side with an armored wall between. While there is a saving of weight by this arrangement, only two guns probably can be fired at once. Effective gun fire in the next battle at sea will be that which provides for a simultaneous discharge of all the guns with the destructive results which must necessarily ensue from the reproduction of the late "broadside" or the modern salvo.—*Army and Navy Register.*

New German Ships.—Some exhaustive details concerning the dimensions and armament of the German battleships *Ersatz Worth,* "*T,*" and *Ersatz Kaiser Friedrich III.*, have recently been given by *Die Welt der Technik.* They will be 626 feet 7 inches in length, with a beam of 100 feet, and a displacement of 28,500 tons. The armament will consist of eight 15-inch 45-caliber guns in four center-line turrets, sixteen 5.9-inch 50-caliber guns in a central battery; twelve 3.4-inch, and four 30-caliber 2.9-inch for attacking aircraft. The 15-inch gun is stated to weigh 83.8 tons, the shell of 1675.5 lbs. leaving the muzzle with an initial velocity of 2493 foot-seconds. It is estimated that in five minutes the broadside fire of one of these vessels would amount to a total of 620 projectiles—40 15-inch, 280 5.9-inch, and 300 3.4-inch, the total weight being 101,486 lbs.—*United Service Magazine.*

New Italian Ships.—The *Moniteur de la Flotte* gives the names of the four new Italian battleships as follows: *Cristoforo Colombo, Marcantonio Colonna, Caracciolo* and *Francesco Morosini.* A fifth name—*Giovanni da Varazzano*—has also been mentioned; and while the first four are said to apply to ships "*en chantier,*" the fifth is stated to be that of a ship "*qui sera mis en chantier cette année.*" The design is the work of M. Edgardo Ferretti, and the ships will carry eight 15-inch, sixteen 6-inch, and twenty-four 3-inch guns on a displacement of 26,000 tons, the water-line length being 692 feet, the nôminal speed 25 knots (oil fuel being exclusively used), and the thickness of the main belt 13½ inches tapering to one-half of that amount forward and aft.—*United Service Magazine.*

New British Ships.—Contracts for the two battleships of the 1914-15 programme, which the First Lord announced on March 17th were to be accelerated to take the place temporarily of the proposed Canadian "Dreadnoughts," were made in May with the firms of Messrs. Palmer's Shipbuilding and Iron Company, Jarrow, and the Fairfield Shipbuilding and Engineering Company, of Clydebank. The Palmer's vessel will be named the *Repulse,* and that of Messrs. Fairfield the *Renown.* Names have also been chosen for the two dockyard ships. That at Portsmouth will be called the *Agincourt,* this vessel being of the "Queen Elizabeth" class; while that at Devonport will be known as the *Resistance,* as this ship is to be of the "Royal Sovereign" type, of which all the vessels have received names beginning with the initial "R."—*Journal of the Royal United Service Institution.*

BOOK REVIEWS

Uma Solucao do Problema Balistico. (Reprint from *Revista de Artilharia.*) By Antonio de Almeida Lima, Capitao de Mar e Guerra. Lisbon: La Becarre de Francisco J. Carneiro, Rua Nova do Almada, 47. 5¾" x 8½". 55 pp., 9 tables. Paper.

The scope of this treatise is limited to range table computations.

The solution is based upon the application of suitable "factors of fire" to the equation of the trajectory in vacuo, as follows:

$$y = x \tan \varphi - \frac{gx^2}{2 V^2 \cos^2 \varphi} G_y$$

$$\tan \theta = \tan \varphi - \frac{gx}{V^2 \cos^2 \varphi} G_\theta$$

$$t = \frac{V \cos \varphi}{x} G_t$$

$$u = \frac{V}{G_v} = \frac{v \cos \theta}{\cos \varphi}$$

$$v = \frac{u \cos \varphi}{\cos \theta}$$

$$G_v = 1 + \tfrac{2}{3}\, kx + \beta\, k^2 x^2$$

A table showing values of β as a function of V, and formulas, based on the values of K_v as determined by Krupp, are given for computing values of G_y, in the absence of experimental data for a given gun and projectile.

Interesting and valuable formulas amd methods for computing k from experimental firings are also given.

The principal unique feature is the ballistic tables, where, for each 100 m.-s. of V, from 300 m.-s. to 900 m.-s., inclusive, are given values of G_v, u, G, and G_t as functions of G_y. This method thus makes the remaining elements functions of G_y, and is certainly as legitimate as making them functions of V, C, and X, as is our practice. The methods employed in determining the value of k are as satisfactory and reliable as those used by us in determining the value of the coefficient of reduction to be applied to C. Either of these methods will lead to the establishment of a satisfactory φ, X, relation; but until more is known regarding atmospheric stream lines, at the velocities employed in exterior ballistics, and the effects of the gyroscopic motion of the projectile on these stream lines, and on the acceleration along the radius vector of the trajectory, the remaining elements of the range table, with the exception of T, can only be approximately determined. In the case of T, compensation can usually be had, and becomes necessary in curved and high-angle fire.

The tables are computed for the nearest integral values of n for the well-known law of air resistance:

$$Cr = Av^n$$

The values of V for which n is assumed integral are: $n=2$, $V=900$ m.-s.; $n=3$, $V=600$ m.-s.; $n=4$, $V=400$ m.-s. These values should be satisfactory for the purposes for which they are employed, were it not for the fact that the same value of n is used throughout a given table. This latter defect will be of minor importance for medium velocities and small values of φ, but for high velocities with long ranges, or for curved fire, compensation would be required. The author gives a quite extended application of his tables to practical problems, and presents an interesting solution of a trajectory divided into arcs.

One misprint is noted on page 26, where

$$\sin^2 \varphi = X \frac{V^2}{g} G_y$$

is printed for

$$\sin 2\varphi = X \frac{g}{V^2} G_y$$

The book is well arranged and neatly printed, the views of the author are clearly set forth, the tables are convenient, and the whole forms a valuable contribution to the literature of exterior ballistics.

As a manual for computing range tables, it is deficient, according to our practice, as it supplies no means for determining the drift and deflection corrections, or range corrections for variation of the ballistic elements from standard conditions.

✤ ✤ ✤

Training in Night Movements Based on Actual Experiences in War. Translated from the Japanese by First Lieutenant C. Burnett, Fourth U. S. Cavalry. Agents: U. S. Cavalry Association, Fort Leavenworth, Kansas. 5¾" x 8½". 133 pp. 14 il. Cloth. 1914. Price, $1.00 postpaid.

We are indebted to the translator for the opportunity of studying at close range the methods of training employed in the Japanese army, and for the inspiration to painstaking care in minute details that must result therefrom. One cannot but be forcibly impressed by this exhibition of tireless drill in minutiæ in time of peace for the purpose of avoiding gaining experience in war at the expense of failure, or of only partial success. The Japanese are determined to accomplish by rehearsal amongst themselves what others are tempted to leave to be learned by unpleasant experience with an enemy.

An excellent example of Japanese painstaking training in peace is afforded by Chapter VIII, "Training in Hearing at Night," in which the method for training in the noise of intrenching is as follows: "For example, have the necessary number of men advance from the squad at A, in the direction of B. Having faced the squad at A to the rear, have them listen to the noise of intrenching at B; when they can no longer hear it, halt the squad at B, and estimate the distance. Again, have a squad at B, approach the squad at A; when the latter can hear the noise, have them estimate the distance. * * * By such means, each man, individually, will learn the proper pace and manner of advance; the noise of working, also, will teach them (sic) how to use their tools with a minimum of noise."

The extent to which rehearsal is carried in Japanese training appears

from Chapter XX, "Training in Night Bayonet Fencing": "In this training, the instructor—Non-Commissioned Officer, or First Class Private—wears defensive armor, and if necessary, face armor as well. The soldiers under instruction wear fencing gloves only, or the regulation clothing. The instructor calls out a name, and the soldier charges several times, being relieved in turn. At this time the soldier must be taught not to fear the instructor's bayonet, but he must be made to approach very close to the instructor. Try to make the exercise as realistic as possible. On moonlight nights, this exercise will conform to that of the daytime, but the best way to take advantage of the light can be studied."

The Japanese practise, not only attention to detail in time of war, but training in it in time of peace.

There being thirty-nine chapters in the volume, the subjects of all cannot be given here; but as being among the more important will be mentioned: "How to Dress"; "Training in Dressing"; "Training Night Vision"; "Training in Hearing at Night"; "Training in Determining Direction"; "Method of Making a Light at Night"; "Training of Night Sentinels"; "Training of Night Patrols"; and "Night Battles."

There are two chapters on the psychology of night training; but the lack of care in translation, which is confessed in the preface, is such as to render subtilties of psychology indistinguishable. In fact, it is regretted that, in all justice, the reviewer must state that the volume abounds in errors of English as well as of typography.

✣ ✣ ✣

Military Education in the United States. By Captain Ira L. Reeves, U. S. Army. Press of Free Press Printing Company, Burlington, Vermont. 6½" x 9½". 431 pp. 35 il. 1914. Cloth.

To desire to fight for fighting's sake is not noble, but to be unwilling to make the sacrifice involved may be far less noble. George Meredith said, "A people notoriously craving peace for comfort and for commerce's sake they do but provoke contempt." A nation, like an individual, must look to the motive underlying its desire for peace: if that desire is born of good will, well; but if of fear of sacrifice, that sacrifice will be exacted in full measure, whether by war or otherwise.

St. Paul, in exhorting the Corinthians to effort in spiritual strife, reminds them that for winning any prize, athletic or other, preparation and sacrifice are necessary; and it is well in national life that that be kept in mind. The race in which a nation runs is for sovereignty at home and respect abroad—both the fruit of the righteousness which "exalteth a nation." Neither war nor peace is an end: war is a means to an end, while peace is the prize of righteousness. Right must be done, leaving consequences to themselves, and for success in doing the right, preparation and sacrifice are necessary: there is more of righteousness in strength than in weakness.

It is of preparation that the volume we are considering treats. And the necessity for treating of it appears from the author's citation, in his foreword, as an example of the little attention paid to military education in the United States, of "Doctor Andrew S. Draper's book *American Education*, in which the entire space given to military education is contained in the following lines: 'The Military and Naval Academies are wholly subject to the Secretaries of War and Navy, and no distinct schoolman

carries the light of his guild into the recesses of their affairs.'" Professor J. Franklin Messenger, of the University of Vermont, in his introduction to the volume, also bears testimony to the lack of evidence of regard for military education in the United States, in the following remark: "Since reading the manuscript of Captain Reeves' book I have looked in my own library to see what there was about military education. It is needless to say that I have not found enough to mention."

The manner of treatment of the subject is indicated by the following quotation from the author's acknowledgements: "A book of this character is of necessity largely a matter of compilation. In the present effort a great part of the text is taken from orders issued from the headquarters of the Army, eliminating here and adding there, and frequently changing the language to conform to the general plan."

The volume contains nineteen chapters and seven appendices. The first chapter, "Military Education Generally," gives a brief general history of the earlier education in the Army; the present military educational system; the military educational system of the organized militia; and the military education in foreign countries. The second chapter is devoted to the United States Military Academy at West Point; the third, fourth, and fifth to military education in civil institutions of learning, land grant colleges and universities being treated separately; the sixth to eleventh chapters, inclusive, are devoted to the War College, the schools at Fort Leavenworth, the Coast Artillery School, the Mounted Service School, and the Army Medical School; the twelfth chapter treats of garrison schools for officers; the thirteenth, of post schools for enlisted men; the fourteenth, of schools for bakers and cooks; the fifteenth, of instruction camps for college students; the sixteenth, seventeenth, and eighteenth, of the School of Musketry and the School of Fire for Field Artillery at Fort Sill, and of the Aviation School at San Diego; and the nineteenth chapter treats of the military education of the organized militia.

Under each school, in addition to such matter as has been compiled in the manner stated from War Department orders, there is presented an historical sketch.

The two more important of the appendices present sample sets of examination questions for entrance to West Point, and for appointment to the Army Medical Corps.

The volume makes readily available precise information concerning the military education at present given in the United States, and should do valuable missionary work.

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Apreciacion Militar del Terrenoy Levantamientos Rapidos. By R. Negret and C. Rojas F., officers of the Colombian Army. Tip. Electrica Mogollon Barranquilla, Colombia. Official publication. 4¼" x 6". 98 pp. 17 il. 1914.

General Arzayus, Chief of Staff of the Colombian Army, highly recommends the work for its practical usefulness, simplicity, and terseness; and the Minister of War has ordered it published and prescribed it for study by army officers in qualifying themselves in military reconnaissance.

Napoleon has said: "After genius, a thorough knowledge of the terrain is the principal element of victory." The preface lays stress on the vital

importance of such a knowledge of military topography and sketching on the part of all officers and non-commissioned officers as to put that maxim in practice. This is the more readily attainable, since the subject may be easily taught to all by simple and practical methods.

The following chapters on military reconnaissance are terse and clear, and so expressed as forcibly to impress upon the reader essential principles and practical applications. The volume is of a size that may readily be carried in the field uniform for handy reference. A similar reference book containing only the essentials requisite for mastering the principles of military reconnaissance and sketching, would serve a valuable purpose in our army. The chapters of Part I serve as excellent reminder lists for the officer of limited experience, and for the older officer as well. They show the essentials to be covered in any practical case of reconnaissance likely to arise, and serve as an excellent guide in terrain exercises. General principles to govern all reconnaissance are laid down, stress being placed on the following requisites:

1. Clear grasp of the mission of the reconnaissance.
2. A quick military eye for estimating the uses of terrain in connection with any military situation.
3. Accuracy.
4. Facility in map reading.
5. Full appreciation of all the uses of terrain for military purposes.
6. Celerity in sketching.
7. Ready orientation by day, night, or in close country.

Under the heading, "Military Appreciation of the Terrain," the authors point out the necessity for this fundamental requisite, the correct use of troops, their efficient disposition, and economical distribution depending upon such appreciation.

A brief analysis is made of the interrelation between terrain and the different arms of the service, it being pointed out how infantry, cavalry, and artillery are affected in their employment by conditions of the terrain.

The effects of open country, military roads and lateral communications, intervisibility of points, good cover both for screening and for defilade, and cultivation, are briefly discussed. The influence of the seasons and of the weather is noted. A good analysis is made of road reconnaissance, railway reconnaissance, and the reconnaissance of rivers. The latter is discussed both under fording and bridging. Reconnaissance of obstacles is fully explained and especial attention is given to marshes, lagoons, streams and lakes, steep slopes, woods, and defiles.

Observation of the enemy from concealed positions is explained and described. The influence of the different kinds of terrain in combat, both in attack and in defense, is tersely and clearly noted.

The form of written report to accompany all reconnaissances must follow a systematic scheme and certain general rules, which are carefully laid down for ready reference.

The Second Part deals with military sketching and map-making under the sub-heads: general principles, making the rough sketch, measurement of distances, angles and heights, contouring, and finishing the sketch or military map. Graphic scales and vertical intervals, angles of slope, and gradients also are included.

A model form for field notes is given, and the appendix contains formulæ

to be used in map reading and map problems, such as problems involving the intervisibility of points on the map, etc.

This work has been carefully coordinated with the Colombian Infantry and Artillery Drill Regulations, Field Service Regulations, and Conventional Symbols Manual, as well as with the lectures delivered in the Army War College in the staff courses of 1910-1911.

It compresses within its small volume a large amount of valuable practical information, tersely, clearly, and forcibly expressed and readily accessible for use in the field.

As previously remarked, a similar work would prove very useful in our own service.

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American Policy. The Western Hemisphere in Its Relation to the Eastern. By Major John Bigelow, U. S. Army, Retired. New York City: Charles Scribner's Sons, Fifth Ave. and 48th Street. 5¼" x 7¾". 175 pp. 1914. Price, $1.00.

This is an excellent brief history of American policy—"American" being used to include, not the United States alone, but "the independent countries of North, South, and Central America." In contains four chapters, of which the subjects are: I. Population and Government; II. The Washington Precept. The Monroe Doctrine; III. Cases under the Monroe Doctrine; and IV. The Bolivar Idea. Conclusion.

Each chapter has much of interest, but probably the third, "Cases under the Monroe Doctrine," has most; and for citizens of the United States that chapter affords food for serious thought. The misfortune, not to say shame, involved in the Clayton-Bulwer Treaty is forcibly borne upon the reader, as is also the travesty of justice in the Venezuelan boundary affair.

In his conclusion the author expresses the opinion that "the most important friendship for Pan America to cultivate is that of Japan and Russia." And he goes on to say: "It should seek to attach those powers to it and to reconcile them to each other. Befriended by these powerful empires and the lusty republic of China, Pan America may proceed down the vista of the ages, decking it with the trophies of peace, with prizes of art, of science, and of commerce * * *."

This little volume is recommended to the busy man as a ready means of acquiring a fairly comprehensive view of those matters American that are now so prominent.

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Our Many-Sided Navy. By Robert W. Neeser, New Haven, Conn.: Yale University Press, 209 Elm Street. 6¾" x 9¾". 220 pp. 40 il. Cloth. 1914. Price $2.50, postpaid.

To one in a sister service, upon reading "Our Many-Sided Navy," there suggests itself a great desire for so wise and faithful an advocate with the people. The author is to be complimented and the Nation and the Navy congratulated.

The descriptions are picturesque and sympathetic, and, withal, accurate (barring an occasional statement inspired by extreme enthusiasm; such, for instance, as that made in the footnote to page 166, to the effect that, with

the 12-inch naval gun, firing with accuracy is practicable at a range of 24,900 yards). If the Nation at large is to learn of the actual life and spirit of its Navy, it must be through works such as this.

Among the many sides treated of are: The Fleet at Sea; The Naval Station at Guantanamo Bay; The Organization of the Ship; The Bluejacket's Daily Life; the Battleship as an Educational Institution; The Engineering Competitions; Athletics in the Navy; The Sailor as Soldier; The Work of the Torpedo Flotilla; Gunnery Training; and Target Practice.

While other chapters, notably that on Organization of the Ship and the Bluejacket's Daily Life, give an intimate insight of modern life afloat, yet the chapter on the Engineering Competitions probably best accentuates the difference between the old and the new, and typifies the spirit of the new, in naval organization and administration. For the American citizen this is the chapter of greatest import.

How fortunate the Navy has been in the bestowal upon it of trophies for the encouragement of sports, appears from the chapter on athletics. And, though here again a member of a sister service may be tempted to envy, yet does the chapter not in fact give him food for thought? There is much in the chapter on athletics to be inwardly digested by Army readers.

"Our Many-Sided Navy" affords every American citizen an opportunity really to know the work and the life of his Navy.

✦ ✦ ✦

Manual of Military Hygiene for the Military Services of the United States. Published under authority and with the approval of the Surgeon General, U. S. Army. By V. Havard, M. D., Colonel, Medical Corps, U. S. Army, Retired. New York: Messrs. William Wood & Co., 51 Fifth Avenue. 6¼" x 8¾". 786 pp. 251 il. Price, $5.00.

This second edition of Colonel Havard's excellent book contains over 250 engravings and nearly 800 pages of text; but by the use of thinner and suitable paper, the size and weight are reduced rather than increased over the first edition.

This handbook presents, in a clear and concise manner, the art and science of military hygiene, and is designed to give an accurate comprehension of the principles which underlie measures of sanitation. It treats of the soldier in garrison, on the march, and in camp; of his foods, drinks, habits, clothing, exercises, and diseases. The chapters on camp sanitation and the care of the soldier in the field, are particularly instructive and readable.

Because of the signal importance of a knowledge of hygiene and sanitation in garrison as well as in the field, the book is commended, not only to the medical officers of the regular, volunteer, and organized militia forces, but also to the staff and line officers of each of those forces.

✦ ✦ ✦

L. L. Poates & Co's Handy Atlas of the World. New York: L. L. Poates & Company. 6" x 8¼". 75 pages maps and 20 pages index. 1914. Price: cloth, $0.50; leather, $1.00.

This "Handy Atlas," in leather, weighs seven ounces, thereby, in conjunction with its dimensions, justifying its name.

It contains seventy-five pages of maps, all of which are single page

maps, 5 in. x 7 in., with the exception of the map of the world and the map of the United States, which are double page maps. The remaining seventy-one pages of maps are assigned as follows: 1 to Alaska; 47 to the forty-eight states of the Union, Maryland and Delaware being presented on one; 1 to the Hawaiian Islands and Porto Rico; 1 to the Panama Canal and the Canal Zone; 1 to the Dominion of Canada and Newfoundland; 7 to the provinces of the Dominion; 1 to Mexico; 1 to Central America; 1 to the West Indies; 1 to Cuba; 6 to the great continents, including Australia; 1 to the Artic Regions; and 1 to the Antartic Regions.

The maps are in three colors, water being shown in blue and mountains in dark relief; and the names of railroads, are indicated. All names are remarkably clear.

In addition to the seventy-five pages of maps, there is, in the front of the volume, one page devoted to an alphabetical index of states and countries; and, at the back, eleven pages devoted to a list of the principal cities and towns of the United States with their populations under the 1910 census, and seven and a fraction pages devoted to an alphabetical index of the important cities of the world, outside of the United States, with their populations.

The atlas is a convenient volume to have on one's desk.

✤ ✤ ✤

Le Chauffage Economique de l'Habitation. Paris: Mois Scientifique et Industriel, 8 Rue Nouvelle. 6¼" x 9½". 90 + 26 pp. 72 il. Paper. 1913. Price 2 fr. 75.

"When arranging for the heating of a new building, or one that hitherto has not been heated," says the introduction, "choice must be made from among various systems, and one often is in doubt as to how to decide; or, when a house is provided with a heating system that is not wholly satisfactory, one wonders whether it is not possible to convert it or to improve it. It is the same with ventilation. Both questions call for the solution of problems which demand acquaintance with the characteristics of the various systems, whether of heating or ventilation—acquaintance with their advantages and their disadvantages; and it is for the purpose of supplying exactly that acquaintance that this work has been prepared. Its object is to enable one to select from among various systems the particular one that best suits his purpose, or to decide what changes he should have made in his installation in order to improve its operation or effect."

The volume is composed of nine chapters and an appendix.

The subjects of the nine chapters are: 1. Requirements for successful heating—fuels. 2. Fire-places. 3. Stoves. 4. Heating by hot air. 5. Heating by hot water. 6. Steam heating. 7. Comparison of the various methods for regulating the temperature. 8. Special arrangements for heating factories and shops. 9. Ventilation and cooling.

The appendix presents the conditions of a problem in heating from a central plant and its solution in four ways—by stove, hot air, hot water, and steam.

The volume is useful to any one, in that it presents tersely practical information and general principles concerning a subject of common interest; but, of course, its usefulness to persons outside Europe is limited to a certain extent by differences in types of installation.

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Index to Current Military Literature

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KEY

TO

INDEX TO CURRENT MILITARY LITERATURE

The periodicals cited are arranged by government, and each periodical is assigned a symbol consisting of an initial, or other abbreviation of the governmental designation, and a numeral indicative of the periodical's position in an alphabetical arrangement of the Journal of the United States Artillery's exchanges under that government.

Prices of subscription are given in the currencies of the countries of publication.

All the periodicals cited are preserved in the Library of the Coast Artillery School at Fort Monroe, Virginia.

ARGENTINE

Ar-0.5	*Anuario del Instituto Geografico Militar de la Republica Argentina*	
	3ª Division del Estado Mayor del Ejército	Annual
	Buenos Aires	
Ar-1	*Boletin del Centro Naval*	Bimonthly
	Florida 659, Buenos Aires	Per year $\$^{m}/_{n}11.90$
Ar-1.5	*Revista del Circulo Militar*	Monthly
	255 Maipu	Per year \$12.00
	Buenos Aires	
Ar-2	*Revista Militar*	Monthly
	Ministerio de Guerra, Santa Fe 1461	Per year $\$^{m}/_{n}9.00$
	Buenos Aires	

AUSTRIA

Au-1	*Mitteilungen aus dem Gebiete des Seewesens*	Monthly
	Pola	Per year 17 M
Au-2	*Mitteilungen ueber Gegenstaende des Artillerie-und Genie-Wesens*	
	Getreidemarkt 9	Monthly
	Wien, VI.	Per year 20 M
Au-3	*Streffleurs Militaerische Zeitschrift zugleich Organ der militaerwissenschaftlichen Vereine*	Monthly
	I. Graben, 13. Wien	Per year 28 M
Au-3.5	*Streffleurs Militaerblatt*	
	Verlag L. W. Seidel & Sohn, k.u.k.	Weekly
	Hofbuchhandler, Wien	Per year 16 M
Au-4	*Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*	
	I. Eschenbachgasse, No. 9	Weekly
	Wien	Per year 34 K

BELGIUM

Be-1	*Belgique Militaire, La*	Weekly
	Rue Albert de Latour 50	Per year 12 fr 50
	Schaerbeck, Brussels	

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The periodicals cited are arranged by government, and each periodical is assigned a symbol consisting of an initial, or other abbreviation of the governmental designation, and a numeral indicative of the periodical's position in an alphabetical arrangement of the Journal of the United States Artillery's exchanges under that government.

Prices of subscription are given in the currencies of the countries of publication.

All the periodicals cited are preserved in the Library of the Coast Artillery School at Fort Monroe, Virginia.

ARGENTINE

Ar-0.5	*Anuario del Instituto Geografico Militar de la Republica Argentina*	
	3ª Division del Estado Mayor del Ejército	Annual
	Buenos Aires	
Ar-1	*Boletin del Centro Naval*	Bimonthly
	Florida 659, Buenos Aires	Per year $\$^{m}/_{n}$11.90
Ar-1.5	*Revista del Circulo Militar*	Monthly
	255 Maipu	Per year $12.00
	Buenos Aires	
Ar-2	*Revista Militar*	Monthly
	Ministerio de Guerra, Santa Fe 1461	Per year $\$^{m}/_{n}$9.00
	Buenos Aires	

AUSTRIA

Au-1	*Mitteilungen aus dem Gebiete des Seewesens*	Monthly
	Pola	Per year 17 M
Au-2	*Mitteilungen ueber Gegenstaende des Artillerie-und Genie-Wesens*	
	Getreidemarkt 9	Monthly
	Wien, VI.	Per year 20 M
Au-3	*Streffleurs Militaerische Zeitschrift zugleich Organ der militaerwissenschaftlichen Vereine*	Monthly
	I. Graben, 13. Wien	Per year 28 M
Au-3.5	*Streffleurs Militaerblatt*	
	Verlag L. W. Seidel & Sohn, k.u.k	Weekly
	Hofbuchhandler, Wien	Per year 16 M
Au-4	*Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*	
	I. Eschenbachgasse, No. 9	Weekly
	Wien	Per year 34 K

BELGIUM

Be-1	*Belgique Militaire, La*	Weekly
	Rue Albert de Latour 50	Per year 12 fr 50
	Schaerbeck, Brussels	

Be–2	*Revue de l'Armée Belge* 24 Rue des Guillemins, Liege	Bimonthly Per year 13 fr
Be–3	*Revue de l'Ingénieur et Index Technique* 70, Boulevard d'Anderlecht, Brussels	Quarterly Per year 30 fr

BRAZIL

Br–1	*Boletim Mensal do Estado Maior do Exercito* Ministerio de Guerra Rio de Janeiro	Monthly
Br–2	*O Tiro* Rio de Janeiro	Monthly
Br–3	*Revista Maritima Brazileira* Rua D. Manoel n. 15 Rio de Janeiro	Monthly Per year 12$000

CHILE

C–1	*Memorial del Estado Mayor del Ejercito de Chile* Talleres del Estado Mayor-General Santiago	Monthly
C–2	*Revista de Marina* Casilla del Correo 976, Valparaiso	Monthly Per year $15.00

COLOMBIA

Co–1	*Memorial del Estado Mayor del Ejercito de Colombia* Jefe del Departamento de Historia del Estado Mayor-General Bogota	Bimonthly Per year $0 50 oro

DENMARK

D–0.5	*Dansk Artilleri-Tidsskrift* Copenhagen	Bimonthly Per year 5 kr
D–1	*Militært Tidsskrift* Copenhagen	Semimonthly Per year 8 kr

DOMINICAN REPUBLIC

DR–1	*El Porvenir Militar* Salome Urena No. 8 Santo Domingo	Monthly

ECUADOR

E–1	*Boletin del Estado Mayor General* Quito	Monthly Per year $4.00

FRANCE

F–1	*Archives Militaires, Les* Librairie Militaire Berger-Levrault 5-7 Rue des Beaux-Arts, Paris	Quarterly Per year 14 fr
F–2	*France Militaire, La* 10 Rue Danton, Paris	Daily Per year 32 fr
F–3	*Génie Civil, Le* 6 Rue de la Chaussée d'Antin, Paris	Weekly Per year 45 fr
F–4	*Journal des Sciences Militaires* 30 Rue Dauphine, Paris	Weekly Per year 40 fr

F-5	*Liste Navale Francaise* Quai Cronstadt, au coin de la Rue Neuve Toulon	Quarterly Per year 9 fr
F-6	*Memoires et Travaux de la Société des Ingénieurs Civils* 19 Rue Blanche Paris	Monthly Per year 36 fr
F-7	*Memorial des Poudres et Salpetres* 55 Quai des Grands-Augustins, Paris	Semiannually Per year 13 fr
F-8	*Mois Scientifique et Industriel, Le* 8, Rue Nouvelle, Paris	Monthly Per year 25 fr
F-9	*Monde Militaire, Le* 6 Rue de la Chaise, Paris	Fortnightly Per year 6 fr
F-10	*Revue d'Artillerie* 5 Rue des Beaux-Arts, Paris	Monthly Per year 22 fr
F-11	*Revue de Cavalerie* 5 Rue des Beaux-Arts, Paris	Monthly, ex. Aug Per year 27 fr
F-12	*Revue du Génie Militaire* 5 Rue des Beaux-Arts, Paris	Monthly Per year 27 fr
F-13	*Revue d'Infanterie, La* 10 Rue Danton, Paris	Monthly Per year 25 fr
F-14	*Revue Maritime* 30 Rue et Passage Dauphine, Paris	Monthly Per year 36 fr
F-15	*Revue Militaire des Armées Etrangères* Librairie Chapelot 30 Rue et Passage Dauphine, Paris	Monthly Per year 15 fr
F-16	*Yacht, Le, Journal de la Marine* 55 Rue Chateaudun, Paris	Weekly Per year 32 fr

GERMANY

G-1	*Artilleristische Monatshefte* Bernburgerstr. 24-25 Berlin, S. W. 11	Monthly Per year 27 M
G-2	*Eisen-Zeitung* Verlag von Otto Elsner, Berlin, S. 42	Weekly Per year 12 M
G-3	*Ingenieur, Der* Verlag Buchdruckerei F. Posekel, Gneisenaustrasse 67, Berlin S. 61,	Semimonthly Per year 16 M
G-3.5	*Kriegstechnische Zeitschrift* E. S. Mittler & Sohn Königliche Hofbuchhandlung, Kochstrasse, 68-71, Berlin, S. W.	10 Nos. per yr. Per pear 10 M.
G-4	*Marine Rundschau* Koch Strasse, 68-71, Berlin, S.W.	Monthly Per year 10 M
G-5	*Militaer Wochenblatt* *With monthly Supplement* Koch Strasse, 68, Berlin, S.W., 12	3 times a week Per year 18 M
G-6	*Schiffbau* Zimmerstr. 9, Berlin, S.W., 68	Semimonthly Per year 20 M
G-8	*Ueberall* Verlag: Boll und Pickardt Berlin, N.W. 7	Monthly Per year 15.6 M

G–9	*Zeitschrift fuer das Gesamte Schiess-und Sprengstoffwesen* J. F. Lehmann's Verlag, Paul Heysestrasse 26, Munich	Semimonthly Per year 26 M

HOLLAND

H–1	*Orgaan der Vereeniging ter beoefening van de Krijgswetenschap* Z. O. Buitensingel 224 The Hague	Six Nos. per yr. Per year 4 florins
H–2	*Wetenschappelijk Jaarbericht. Vereeniging ter beoefening van der Krijgswetnschap* Z. O. Buitensingel 224 The Hague	Yearly Per year 2 florins

ITALY

I–1	*Lista Navale Italiana* Officina Poligrafica Italiana, Rome	Quarterly Per year 15 L
I–2	*Rendiconti delle Esperienze e Degli Studi Eseguiti Nello Stabilimento di Esperienze e Costruzioni Aeronautiche del Genio* Viale Giulio Cesare N. 2, Rome	Occasional Per year 13.50 L
I–3	*Rivista di Artiglieria e Genio* Tipografia Enrico Voghera Via Astalli 15, Rome	Monthly, ex. July Per year 20 L
I–4	*Rivista Marittima* Officina Poligrafica Italiana Rome	Monthly Per year 25 L

MEXICO

M–1	*Boletin de Ingenieros* War Dept., Mexico City	Monthly
M–2	*Revista del Ejercito y Marina* Departamento de Estado Mayor City of Mexico	Monthly

NORWAY

N–1	*Norsk Artilleri-Tidsskrift* Christiania	Bimonthly Per year 6 kr
N–2	*Norsk Militært Tidsskrift* Christiania	Monthly Per year 8 kr

PERU

Pe–1	*Boletin del Ministerio de Guerra y Marina* Apartado de Correo No. 91, Lima	Fortnightly

PORTUGAL

Po–1	*Anais do Club Militar Naval* 43 Rua do Carmo, Lisbon	Monthly Per year 4$200
Po–2	*Revista de Artilharia* Rua do Carmo, 43, 2°., Direito, Lisbon	Monthly Per year 3$000 rs
Po–4	*Revista Militar* Largo da Annunciada, 9, Lisbon	Monthly Per year 3$000 rs

RUSSIA

R-1	*Imperial Nicholai War Academy Recorder, The* St. Petersburg	Monthly Per year 6 rubles
R-2	*News of the Officers' Artillery School* Zarskoye Selo	Monthly Per year 10 rubles

SPAIN

Sp-1	*Informacion Militar del Extranjero* Talleres del Deposito de la Guerra Madrid	Monthly
Sp-2	*Memorial de Artilleria* Museo de Artilleria, Madrid	Monthly Per year 18 ps
Sp-3	*Revista Cientifico-Militar* Paseo de San Juan, 201, Barcelona	Semimonthly Per year 40 ps
Sp-4	*Revista General de Marina* Ministerio de Marina, Madrid	Monthly Per year 25 ps

SWEDEN

Sn-1	*Artilleri-Tidsskrift* Artillerigarden, Stockholm	Bimonthly Per year 6 kr
Sn-2	*Svensk Kustartilleritidskrift* Karlskrona	Quarterly Per year 6 kr

SWITZERLAND

Sd-1	*Allgemeine Schweizerische Militarzeitung* Basel	Weekly Per year 10 fr
Sd-2	*Revue Militaire Suisse* Avenue Juste Olivier, Lausanne	Monthly Per year 15 fr
Sd-3	*Schweizerische Monatschrift fuer Offiziere Aller Waffen* Frauenfeld	Monthly Per year 5 fr
Sd-4	*Schweizerische Zeitschrift fuer Artillerie und Genie* Frauenfeld	Monthly Per year 8 fr

UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ITS COLONIES AND POSSESSIONS

UK-1	*Arms and Explosives* Effingham House Arundel Street, Strand, London, W.C.	Monthly Per year 7s
UK-3	*Army Review, The* Wyman & Sons, Ltd. Fetter Lane, London, E. C.	Quarterly Per copy 1s
UK-4	*Canadian Military Gazette* Room 16, Trust Bldg. Ottawa, Canada	Semimonthly Per year $2.50
UK-5	*Commonwealth Military Journal, The* Melbourne, Australia	Quarterly
UK-6	*Electrician, The* 1, 2 and 3, Salisbury Court, Fleet Street London	Weekly Per year 30s

UK–7	*Electrical Review* 4, Ludgate Hill, London, E. C.	Weekly Per year £1 10s
UK–8	*Engineer, The* 33 Norfolk Street, Strand London, W.C.	Weekly Per year £1 16s
UK–9	*Engineering* 35-36 Bedford Street, Strand London, W.C.	Weekly Per year £1 16s
UK–10	*Iron & Coal Trades Review, The* 165 Strand, London, W. C.	Weekly Per year 27s
UK–10.5	*Journal of the Institution of Mechanical Engineers, The* Storey's Gate, St. James Park, London, S. W.	8 Nos. per year
UK–11	*Journal of the Royal Artillery, The* Woolwich	Monthly Single copy 2s 6d
UK–12	*Journal and Proceedings, Royal Society N. S. W.* 5 Elizabeth St., North Sydney, N. S. W.	
UK–13	*Journal of the Royal United Service Institution* Whitehall, London, S.W.	Monthly Per year 24s
UK–14	*Journal of the United Service Institution of India* Simla, India	Quarterly Per year Rs 8
UK–15	*Junior Institution of Engineers, The* 39 Victoria St., Westminster, S.W. London	Monthly Single copy 1s
UK–17	*Page's Engineering Weekly* 22 Henrietta Street, Covent Garden London, W. C.	Weekly Per year £1 1s
UK–18	*Photographic Journal* 35 Russell Square, London	Occasional Copies 1s each
UK–19	*Proceedings of the Institution of Civil Engineers* Great George St., Westminster, London, S. W.	
UK–20	*Proceedings of the Institution of Mechanical Engineers* Story's Gate St., James Park, London, S. W.	
UK–21	*Royal Engineers Journal, The* Chatham	Monthly Per year 15s
UK–22	*Transactions of the Canadian Institute* 58 Richmond Street, Toronto, Canada	
UK–23	*Transactions of the Canadian Society of Civil Engineers* 176 Mansfield Street Montreal, Canada	
UK–24	*Transactions of the Institution of Naval Architects* 5 Adelphi Terrace, London, W. C.	
UK–25	*United Service Gazette* Caxton House, 11 Gough Square, Fleet Street, London, E. C.	Weekly Per year £1 10s 6d
UK–26	*United Service Magazine* 31, Haymarket London, S. W.	Monthly Per year £1 1s

UNITED STATES

US–1	*Aeronautics* 250 West 54th Street, New York City	Semimonthly Per year $3.00

US-2L	*American Historical Review, The* The Macmillan Company 41 N. Queen Street, Lancaster, Pa., or 66 Fifth Avenue, New York City	Quarterly Per year $4.00
US-3L	*American Journal of International Law, The* Baker, Voorhis & Co., 45 John St., N.Y.	Quarterly Per year $5.00
US-4	*American Journal of Mathematics* Johns Hopkins Press Baltimore, Md.	Quarterly Per year $5.00
US-5	*Arms and The Man* 1502 H Street, N.W., Washington, D. C.	Weekly Per year $3.00
US-6	*Army and Navy Journal* 20 Vesey Street, New York	Weekly Per year $6.00
US-7	*Army and Navy Register* Washington, D. C.	Weekly Per year $3.00
US-8	*Bulletin of the American Geographical Society* Broadway at 156th Street, New York City	Monthly Per year $5.00
US-10	*Bulletin of the American Mathematical Society* 501 West 116th Street, New York	Ten Nos. per yr. Per year $5.00
US-11	*Bulletins and Circulars of the Bureau of Standards* Department of Commerce and Labor Washington, D. C.	
US-12L	*Bulletin of the Pan American Union* Seventeenth and B Streets, N.W. Washington, D. C.	Monthly Per year $2.00
US-13	*Bulletin of Iowa State College* Ames, Iowa	Monthy
US-14	*Bulletin of the University of Illinois* Urbana, Illinois	
US-15	*Bulletins, Circulars and Technical Papers* *Bureau of Mines* Department of the Interior Washington, D. C.	Occasional Free
US-16L	*Canal Record* Ancon, Canal Zone, Isthmus of Panama	Weekly Per copy 5c
US-17.5	*Colliery Engineer, The* Scranton, Pa.	Monthly Per year $2.00
US-17.75 L	*Colonial Wars* 9 Ashburton Place Boston	Quarterly Per year $3.00
US-18	*Compressed Air Magazine* Compressed Air Magazine Co. Easton, Pa.	Monthly Per year $1.50
US-19	*Confederate Veteran* Nashville, Tenn.	Monthly Per year $1.00
US-20	*Craftsman, The* 41 W. 34th Street, New York	Monthly Per year $3.00
US-21	*Electric Journal, The* 200 Ninth Street, Pittsburgh, Pa.	Monthly Per year $1.50

US-21.5	*Electrical Engineering* Dalton, Georgia	Monthly Per year $1.00
US-22	*Electrical Review and Western Electrician* Heisen Building 608 South Dearborn Street, Chicago	Weekly Per year $3.00
US-23	*Electricity and Engineering* 608 South Dearborn Street, Chicago, Ill.	Monthly Per year $1.00
US-24	*Engineering Magazine, The* 140-142 Nassau Street, New York	Monthly Per year $3.00
US-25	*Engineering News* 505 Pearl Street, New York	Weekly Per year $5.00
US-27	*Field Artillery Journal, The* U. S. Field Artillery Association 1701 Pennsylvania Avenue, N.W. Washington, D.C.	Quarterly Per year $3.00
US-28	*Flying and The Aero Club of America Bulletin* 297 Madison Ave., New York	Monthly Per year $3.00
US-29	*General Electric Review* General Electric Company Schenectady, New York	Monthly Per year $2.00
US-30	*Infantry Journal* U. S. Infantry Association 814 Seventeenth Street, N.W Washington, D. C.	Bimonthly Per year $3.00
US-31L	*Journal of American History, The* 3 West 43rd Street, New York	Quarterly Per year $3.00
US-31.5	*Journal of Efficiency Society, Inc.* 29 West 39th Street, New York City	Monthly Per year $3.00
US-33	*Journal of The American Society of Mechanical Engineers, The* 29 West 39th Street, New York City	Monthly Per year $3.00
US-34	*Journal of the American Society of Naval Engineers* Navy Department, Washington, D.C.	Quarterly Per year $5.00
US-35	*Journal of the Association of Engineering Societies* 3817 Olive Street, St. Louis, Mo.	Monthly Per year $3.00
US-36	*Journal of the Franklin Institute* 15 South Seventh Street, Philadelphia, Pa.	Monthly Per year $5.00
US-37	*Journal of the Military Service Institution* Governor's Island, New York	Bimonthly Per year $3.00
US-38	*Journal of the U. S. Artillery* Fort Monroe, Virginia	Bimonthly Per year $2.50
US-39	*Journal of the U. S. Cavalry Association* Fort Leavenworth, Kansas	Quarterly Per year $2.50
US-40	*Journal of the Western Society of Engineers* 1735 Monadnock Block Chicago, Illinois	Monthly ex. July and Aug Per year $3.00
US-41	*Machinery* 49-55 Lafayette Street, New York	Monthly Per year $2.50

US–42	*Metal Industry, The* 99 John Street, New York	Monthly Per year $1.00
US–43	*Military Surgeon, The* 535 North Dearborn Street Chicago, Illinois	Monthly Per year $3.50
US–45L	*National Geographic Magazine, The* Hubbard Memorial Hall Washington, D. C.	Monthly Per year $2.50
US–46	*National Guard Magazine, The* 136-140 East Gay Street Columbus, Ohio	Monthly Per year $1.00
US–47	*Navy, The* Southern Building Washington, D. C.	Monthly Per year $2.00
US–47.5L	*North American Review, The* The North American Review Publishing Company New York City	Monthly Per year $4.00
US–48	*Official Gazette of the United States Patent Office, The* Supt. of Documents, Gov. Printing Office Washington, D. C.	Weekly Per year $5.00
US–49	*Pennsylvania Magazine of History and Biography* Philadelphia, Pa.	Quarterly Per year $3.00
US–50	*Physical Review* 41 North Queen Street, Lancaster, Pa.	Monthly Per year $6.00
US–51	*Polytechnic, The* Troy, N. Y.	10 Nos. per yr. Per year $2.00
US–52	*Popular Mechanics* 6 N. Michigan Boulevard, Chicago, Ill.	Monthly Per year $1.50
US–54L	*Proceedings of the American Institute of Electrical Engineers* 33 West 39th Street New York	Monthly Per year $10.00
US–55	*Proceedings of the American Philosophical Society* 104 South Fifth Street, Philadelphia, Pa.	
US–56	*Proceedings of the American Society of Civil Engineers* 220 West 57th Street New York	10 Nos. per year Per year $8.00
US–57	*Proceedings of The Engineers' Club of Philadelphia* 1317 Spruce Street Philadelphia, Pa.	Quarterly Per Vol. $2.00
US–58	*Proceedings of The Engineers' Society of Western Pennsylvania* 2511 Oliver Building Pittsburgh, Pa.	10 Nos. per year Per year $5.00
US–59	*Proceedings of the U. S. Naval Institute* Annapolis, Md.	Bimonthly Per year $3.00
US–60	*Professional Memoirs* Washington Barracks, D. C.	Bimonthly Per year $3.00
US–61	*Reactions* Goldschmidt Thermit Company 90 West Street, New York	Quarterly Per year $0.25

US–64	*Science Conspectus* Massachusetts Institute of Technology Boston, Mass.	Five issues per yr.
US–65	*Scientific American* 361 Broadway, New York	Weekly Per year $3.00
US–66L	*Scientific American Supplement* 361 Broadway, New York	Weekly Per year $5.00
US–68	*Seventh Regiment Gazette, The* 30 West 33rd Street, New York	Monthly Per year $1.50
US–71	*Stevens Indicator* Stevens Institute of Technology Hoboken, N. J.	Quarterly Per year $1.50
US–72	*Technical World Magazine* 5758 Drexel Avenue, Chicago, Ill.	Monthly Per year $1.50
US–73	*Telephone Engineer* Monadnock Building, Chicago, Ill.	Monthly Per year $2.00
US–74	*Transactions of the American Society of Civil Engineers* 220 West 57th Street, New York	Yearly Per year $12.00
US–75	*Transactions of the Society of Naval Architects and Marine Engineers* 29 West 39th Street, New York	Annual
US–76L	*Virginia Magazine of History and Biography, The* Virginia Historical Society Richmond, Va.	Quarterly Per year $5.00

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Aerostation

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Aircraft as a military asset—US-28, June, 14.
Airships as carriers of communications—Au-3.5, June 20, 14.
Aircraft in war. (A lecture delivered at the Royal Artillery Institution, on Thursday, November 6, 1913)—UK-11, May, 14.
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Air-reconnaissance in a siege war—G-5, June 9, 14.
Aeroplane hangars of the Italian type—I-3, March, 14.
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Aerial-land and aerial-maritime warfare—US-3L, April, 14.
Aeroplanes: Launching from and landing on ships at sea—Au-3, March, 14.
Armored aeroplanes in France—G-3.5, May, 14.
Aircraft in war—US-37, July-August, 14.
The development of the aeroplane—I.—US-66L, June 6, 14; UK-9, May 29, 14.
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'The German naval architects (Zeppelin airships)—UK-8, June 12, 14.
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Recent technical developments in military aeronautics—US-28, June, 14.
Reconnaissance by means of aeroplane and dirigible—G-5, June 13, 14.
A skeleton history of the fourth arm—UK-5, April, 14.
Transmission of messages from an aeroplane—G-3.5, May, 14.
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The high commanding authority in a fortress—D-0.5, May, 14.
A study of the organization and operation of ordnance establishments—F-10, April, 14.
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Armies by Country

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Austria:
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Belgium:
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The Belgian army in its new form—Sd-1, June 27, 14.
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Denmark:
Denmark: Its geography, communications, history, and defense system—UK-3, July, 14.
Dominican Republic:
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France:
The French cavalry—Sd-3, April, 14.
How to improve the concentration of our army—F-4, June 6, 14.
The quartering and sanitary conditions of the French army—G-5, June 25, 14.
State of instruction in the infantry—F-4, May 16, 14.
Three year law in France—N-2, May, 14.
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The German naval architects. (Zeppelin airships)—UK-8, June 12, 14.
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Errata

Page 269, legend of figure: For 1892 read 1902.

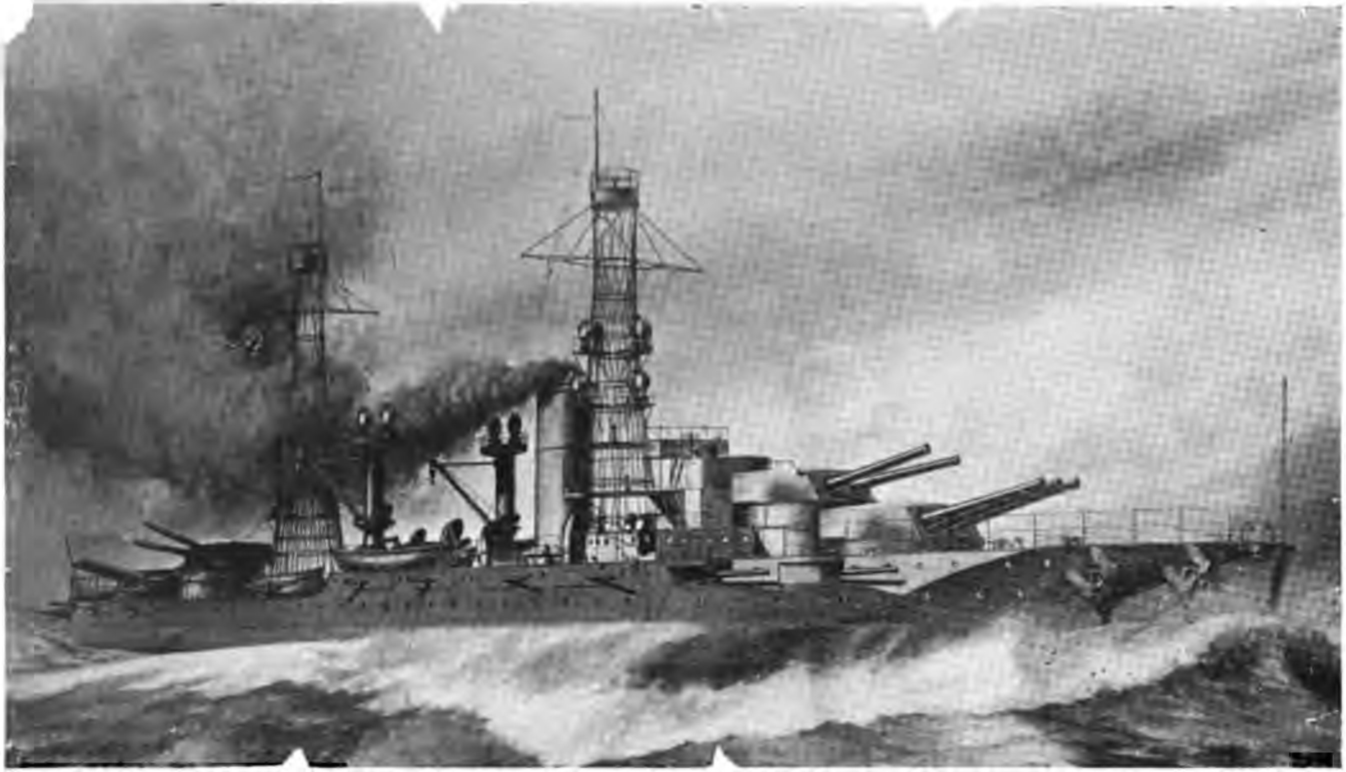
Page 299, first equation: For $.10\frac{\delta_1}{\delta}$ read $.01\frac{\delta_1}{\delta}$.

Corrigenda

JOURNAL OF THE UNITED STATES ARTILLERY
SEPTEMBER-OCTOBER, 1914.

Page 148, paragraph 40, line 6: For "degrees" read *ampères*.

Page 149, table, last column, 14th entry: For ".76" read *.176*.



Photograph by Boston Photo News Co. 1493

U. S. S. "NEVADA"

Sketch by W. Kolvig, copyright 1912, of the battleship as it will appear when completed.

(See pages 251 and 252.)

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TEST OF SEARCHLIGHT CARBONS

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1. A preliminary study was undertaken with a view to a decision on the considerations which should govern in the selection of a searchlight carbon and to an investigation of the methods which were utilized by commercial manufacturing firms, technical testing laboratories, and purchasing agents, both in this country and abroad, in testing the various types of carbons.

2. The value of a searchlight is measured by its ability continuously to illuminate a target and will vary with the light intensity at the source, the average candle-power which falls on the searchlight mirror, the quality of the mirror, the percentage of light absorbed in the mirror and window, or lost due to dispersion, the state of the atmosphere as regards smoke, moisture, etc., and with the functioning of the lamp mechanism. A choice of the best type of carbon will follow a determination of that one which most nearly fulfills the following conditions:

a. It should give the maximum average illumination over the surface of the mirror.

b. It should burn continuously and quietly in the service searchlight with the minimum of attention from the operator.

c. The characteristics of burning should best fulfill the tactical requirements governing the use of the searchlight.

d. The life should be such as to require the least possible number of interruptions.

e. It should be of domestic manufacture.
f. The cost should be reasonable.

3. Upon investigation, it developed that in the tests which had been conducted in this country to determine the relative efficiency of the various carbons as sources of light for searchlights, the conclusions had been based solely on a determination of the steadiness of the arc, the amount of illumination secured from the beam being purely a matter of conjecture. There had been no study made of the photometry of a searchlight beam and there were no accepted methods of conducting such tests. As the practical usefulness of the searchlight depended almost altogether on the average amount of light available for projection from the mirror, it was decided that a photometric determination of the amount of light in the beam, when using various types of carbons, would give the most reliable data by which to compare the relative values of different carbons. Therefore, arrangements were made to conduct the test so as to arrive at conclusions based on the amount of light in the beam.

4. As a result of the initial study, the following general outline of operations was decided upon and followed during the test:

a. Preliminary runs with all the different carbons available, including those of foreign as well as domestic manufacture, to determine from photometric measurements those whose performances warranted further test and to develop practicable methods of procedure in conducting the regular runs.

b. An extended series of competitive runs with all carbons deemed worthly of further test, to determine which type gave the best results in a service searchlight, judged by the amount of light emitted, qualities of burning, and ease of operation.

c. An extended series of runs with the same carbons in the laboratory, to determine the mean spherical candle power over the aperture of 120° usually occupied by the mirror.

d. A series of runs to try out various modifications in the shape, current, voltage, length of arc, etc., of the type carbon in order to decide on the details of specifications and to improve the operation.

e. A trial of various devices on the searchlight designed to improve the operation of the lamp.

f. A series of runs with the carbons made under factory conditions, to revise the specifications based on the performance of carbons made in the laboratory.

g. A series of runs with the factory-made carbons to decide on rules and regulations for the guidance of fire commanders, searchlight officers, and operators in the operation of the light.

h. A series of runs with special type of carbons.

i. A series of runs with 36-inch, 30-inch, and 24-inch carbons to decide on the type and details of specifications.

Preliminary Test

5. A standard 60-inch searchlight, with rotating device from the laboratory of the Department of Engineering and Mine Defense, was installed in a building on the parapet at Fort Monroe, and equipped with recording instruments to give the line voltage, the arc voltage, and the line current. Special devices were also provided to interrupt the feeding magnet circuit, to measure the focal distance and the length of arc, to regulate the feeding voltage, and to control the line voltage from the searchlight room.

6. One of the position finding stations at Fort Wool was fitted up as a photometer station, being equipped with a Sharp-Millar photometer and connected by telephone to the searchlight house.

7. It was considered very important to secure a carbon of domestic manufacture, if practicable; so inquiry was made as to the facilities possessed by various firms for work of this character. The National Carbon Company was the only firm in this country which was prepared to manufacture 60-inch searchlight carbons, and expressed a willingness to enter upon an extended program of experimentation, offering the assistance of its illuminating engineering staff and laboratory in furtherance of the test. Its representative, Mr. H. M. St. John, arrived on October 14th, 1912, with seven different types of carbons which had been developed and manufactured in the engineering laboratory of the company. These carbons were numbered from 1480 to 1487, No. 1480 being the carbon as now issued to the service. As Mr. St. John's time was limited, it was decided to make short runs of 1½ hours each with the different carbons in comparison with the Siemens, which seemed to be the best foreign carbon on the market. Run No. 1 was made for the purpose of determining the proper focal length. Runs No. 2 to 23 were made with the different carbons to determine burning and light giving qualities, and

to determine the most satisfactory method of running the subsequent tests. (See pp. 1-56, Appendix, for data.)*

8. As these runs were made to show what the different carbons might be expected to do, only such runs were made as would tend to eliminate from further test those carbons which gave poor results. As a result of the prelimianry test, National Carbon Company carbons Nos. 1482, 1484, and 1486, were eliminated.

9. The preliminary runs showed that 200 ampères, with from 60 to 65 volts across the arc, gave the best results for all carbons; consequently, the remainder of the test was conducted with as nearly a constant current of 200 ampères as it was possible to maintain.

10. Based on the experience gained during the preliminary runs, the following assignment of personnel was decided upon as necessary for the most efficient operation. When the light was burning, one man watched through the colored glass window on the side of the drum and kept the arc as nearly as possible in the center of the positive crater, using for the purpose the up-and-down and the right-and-left shifting devices and the rotating device. It was essential for good operation that this man should have had considerable experience in the manipulation of the searchlight mechanism and should remain constantly on the watch, so as to meet a sudden shifting of the arc and prevent the light from going out. The best results were obtained when the man was able from previous experience to recognize the indications of possible future difficulty and to apply the necessary corrective measures before irregular burning occurred. A second man controlled the beam, read the length of the arc, kept the crater at the focal point, regulated the feeding voltage, and observed the functioning of the lamp mechanism. A third attendant acted as telephone operator, regulated the line current, noted readings on the various instruments, and kept the records.

11. Two reliefs of two men each were used at the photometer station at Fort Wool, one attendant reading the photometer while the other recorded the readings and watched the ammeter. The strain on the eyes rendered it necessary to change reliefs at short intervals.

12. From the experience gained in the preliminary test,

* While the Appendix is not published, references to it are retained for the benefit of members of the service who may be inclined to refer to it in the files of the Department of Engineering and Mine Defense, Coast Artillery School, Fort Monroe, Virginia.

the following method of preheating was found to give the most satisfactory results and was observed in all the subsequent runs. The carbons were placed in the holders with the points in contact and a current of 75 ampères was turned on for ten minutes, in order to bring the carbons gradually from a cold state up to a dry and warm condition, so that when 200 ampères were thrown on no cracks nor strains developed. The small amount of cracking during the burning of 65 pairs of carbons for 5 hours each showed that this was a useful precaution, for carbons which were burned without the preliminary heating showed a tendency to crack and chip.

Regular Test

13. The regular test to determine the advantages and disadvantages for the coast artillery service of the different types of carbons which were available, began on October 28th, 1912, and the searchlight was in operation on every available night except Saturday and Sunday until February 1st, 1913, and on every available day until July 1st, 1913.

14. The following carbons were tried: Conradty; Siemens; and National Carbon Company's Nos. 1480, 1481, 1483, 1485, and 1487. The Conradty and Siemens carbons were the regular commercial factory output of the companies and such as had been purchased for our service. The National Carbon Company's No. 1480 was the standard factory-made carbon issued to our service with the General Electric Company's 60-inch searchlight. Nos. 1481, 1483, 1485, and 1487 were carbons having factory-made shells like those used in No. 1480, but with different core compositions which had been made up and inserted by an improved process in the engineering laboratory of the National Carbon Company.

15. The following method of conducting the trials was observed in order to eliminate the inequalities in the conditions of individual runs, etc. Each carbon was burned for five successive hours. Each make of carbon had two runs against two runs of each of the other makes, as follows: designating one carbon by A and another by B, A was burned from 7 P.M. to 12 P.M. and B from 12 P.M. to 5 A.M. on one night; on the following night B was burned from 7 P.M. to 12 P. M., and A from 12 P.M. to 5 A.M. If the conditions in regard to weather, fog, smoke, etc., changed during the ten hours so as to favor any carbon in its comparison with another, such runs were disregarded. If during the run of the first part of the night

one carbon enjoyed good atmospheric conditions while during the latter part of the night the next carbon had a fog or slight mist, both runs were discarded. The records show only the runs that were retained.

16. Run No. 24, page 57, Appendix, may be taken as a sample of the regular test runs. The records show a detailed account of events that took place at the searchlight, as well as the readings on the photometer. The length of the arc was taken every five minutes, time and duration of outs were noted, and troubles were indicated, as well as any other event that might be of use. Minute readings were taken on the photometer. The distance to Fort Wool was 2000 yards, and readings represent foot-candles at 2000 yards. Telephone communication had been established between the photometer station and the searchlight and the readings were repeated for the benefit of the party at the searchlight, so that adjustment of beam, arc, and focal length could be judged from the readings.

17. It was noticeable that whenever a southwest wind sprang up the run was destroyed, and many nights were lost from fogs, smoke, etc. The temperature, by means of a thermometer which hung between the carbons and mirror, was taken in the case of the last twenty carbons. During the night it was often necessary to raise the beam to permit shipping to pass without interfering with the pilot. When this was done and a reading on the photometer was lost, a note in the column of remarks was made giving the time of the occurrence. Note was made also of a change of the arc with respect to the center of carbons. This disclosed the tendency of the arc to travel over different parts of the negative carbon, compelling a change in the position of the positive carbon. (See pp. 58-333, Appendix, for data.)

18. The comparative table of burning of the different types of carbons, page 135, shows the average performances obtained.

19. Curves showing the average of results obtained from running two carbons of one type against two carbons of another type, under as nearly equal conditions as possible, are shown in Figs 1, 2, and 3. (See pp. 334 to 338, Appendix, for consolidated data.) Fig. 1 compares Siemens with Conradty, Columbia 1480, Columbia 1483, and Columbia 1481; Fig. 2, Siemens with Columbia 1487, and Columbia 1480 with Columbia 1487, 1485, and 1481. Fig. 3 compares Columbia 1487 with Conradty and with Columbia 1481. The curves are plotted with foot-candles as ordinates and time in minutes as

abscissas, each curve representing the performance of two pairs of carbons of each type. The straight line on the left shows the average foot-candles of light projected on to the target at 2000 yards, and the name of the carbon and the number of the run. It developed early that only two of the new makes of the Columbia carbons (Nos. 1481 and 1487) showed favorable results, so only two pairs of each of Nos. 1483 and 1485 were burned.

20. The last set of curves on Fig. 3 is an average of all carbons of each make which were considered useful for comparison; viz., Columbia 1480 (present issue of carbon), Columbia 1481, Columbia 1487, and Siemens. The Conradty carbons were omitted from this set of curves on account of their poor light as compared with the others and on account of trouble in handling them. Examination of the curves and tables shows the present issue of carbons (1480 Columbia) to be inferior to all other carbons tested. The next is the Conradty, then the Siemens, with Columbia 1481 and 1487 in close competition and leading all others.

COMPARATIVE TABLE OF BURNING IN REGULAR TEST

Each pair of carbons burned for five hours.
Six carbons of each kind.

Name of Carbon	Burning per hour. Positive. Inches.	Burning per hour. Negative. Inches.	Rate of burning.	Light out: number of times in 5 hours.	Light out: total time during 5 hrs. Minutes.	Photometer reading. (2000 yards.)	Length of arc. Inches.	Life of carbon. Hours.
Columbia, 1480	1.16	.82	1.40–1	3	.7	.8	1.2	6
Columbia, 1481	.88	.76	1.18–1	2	.3	2.1	.7	8
Columbia, 1487	.96	.84	1.15–1	2	.4	2.1	.8	7
Siemens	1.24	.84	1.48–1	7	2.6	1.4	1.2	6
Conradty	1.12	.70	1.60–1	11	.7	1.2	1.1	6

For data, see pages 335 to 339, Appendix.

21. An examination of the plotted results shows Columbia 1487 to be slightly superior to 1481, both in the amount of light emitted and in the uniformity of burning. The manipulation of this carbon during burning required less attention on the part of the operator. The type of carbon represented in Columbia 1487 was, therefore, the best as judged from the result of the test in the service apparatus.

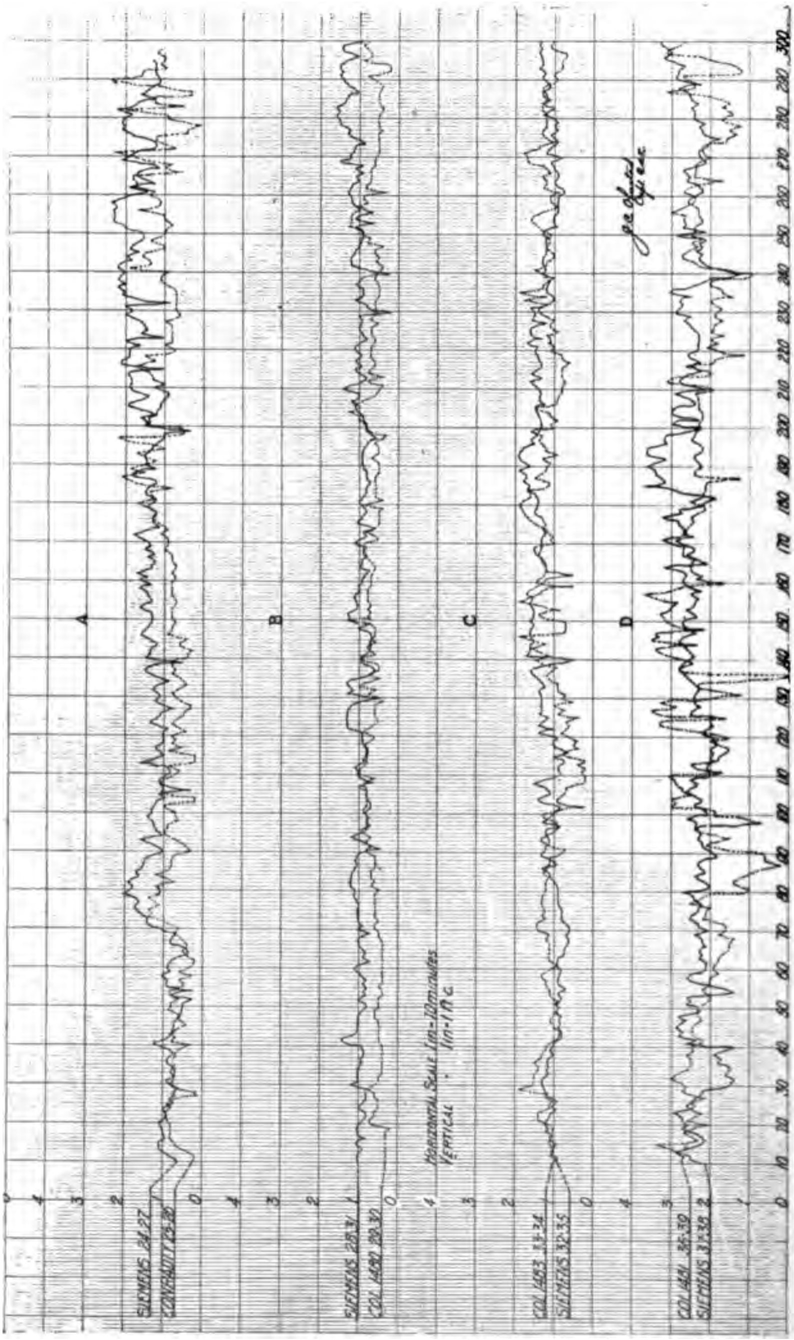


FIG. 1.

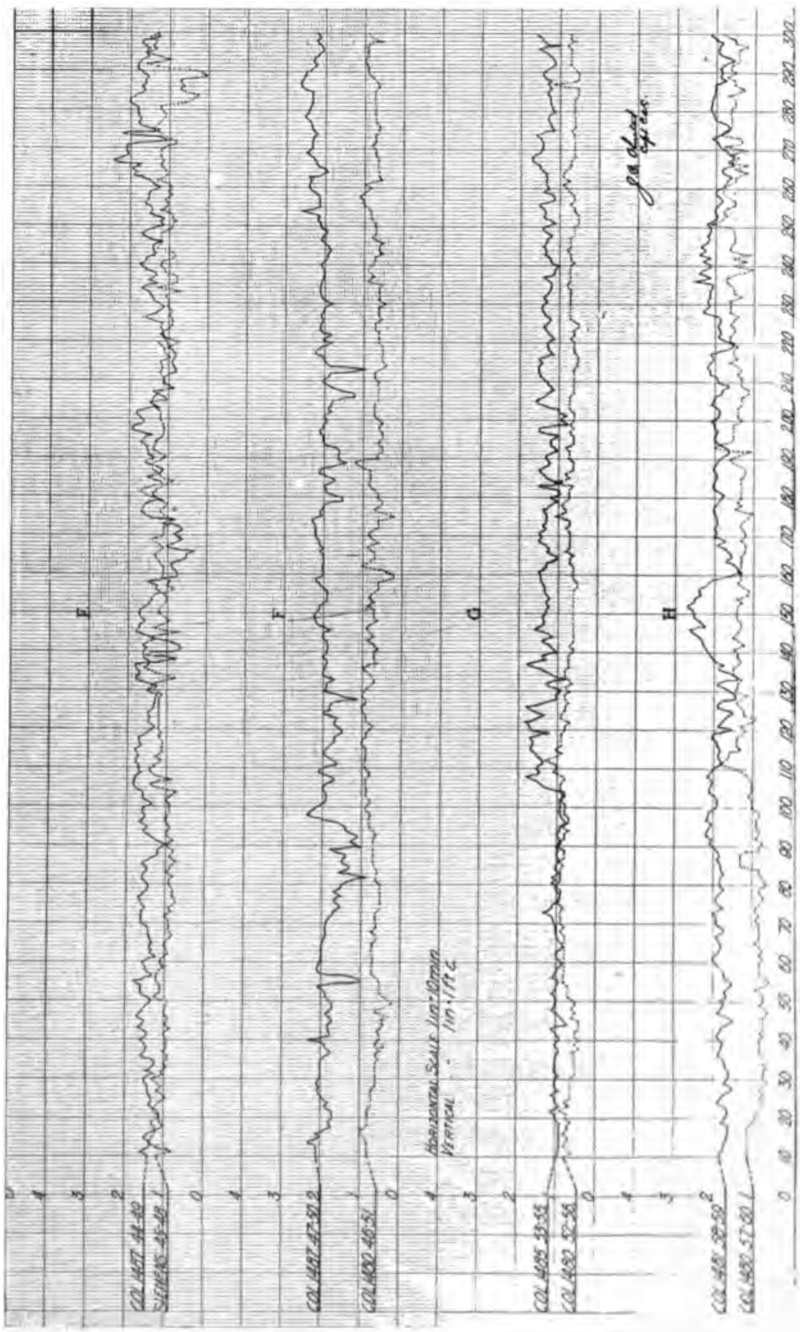
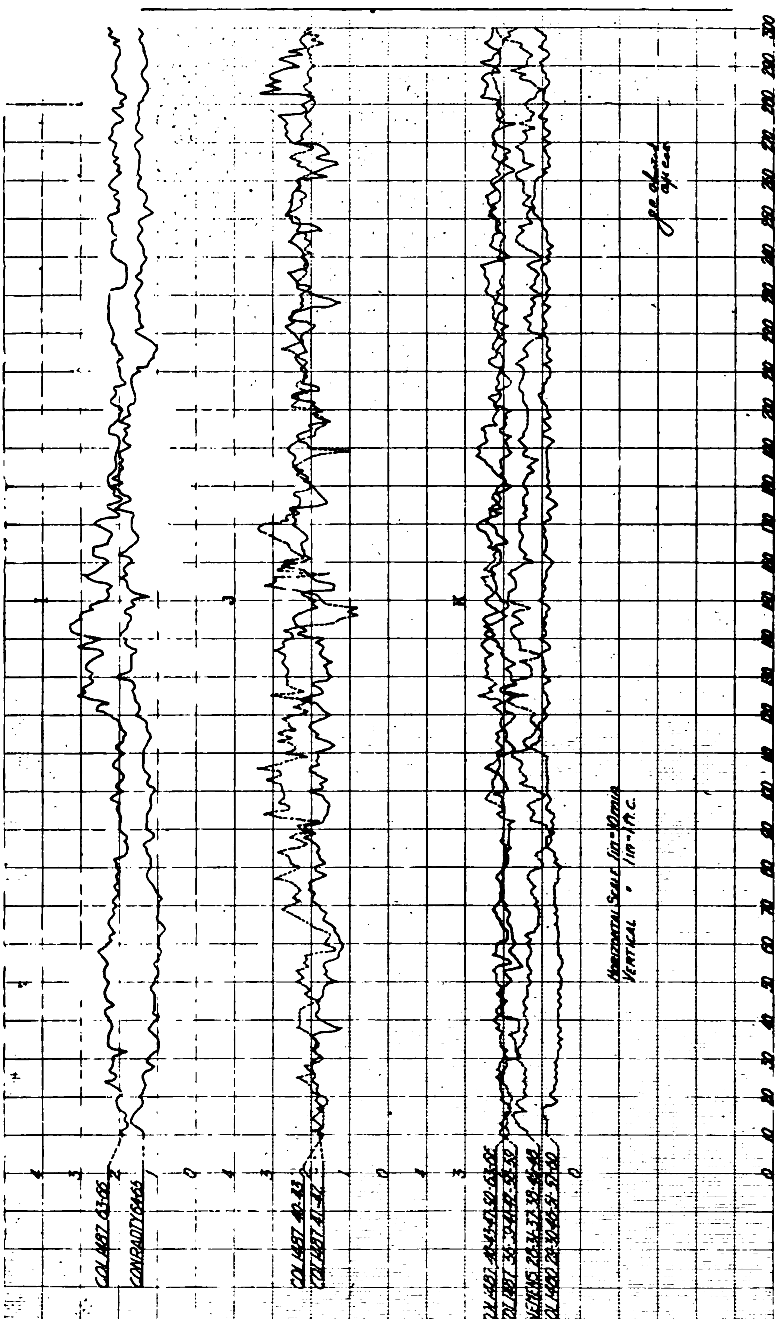


FIG. 2.

1405



1496

FIG. 3.

22. Measurements were taken of all positive and negative carbons at the end of each 5-hour run. The average measurements of the Columbia 1487 carbon were found and an order placed for a new lot of them manufactured with the new shape, with a view to discovering whether there was an appreciable decrease in the length of time required to burn the carbons to shape.

23. In order to determine what effect weather conditions might have on the light, a complete record of barometer, temperature, relative humidity, and direction of wind was made every hour during the run. (See pp. 340-341, Appendix, for data.)

Laboratory Test

24. The test in the service searchlight had given definite results as to the type of carbon best suited for service; but the actual values varied from time to time with atmospheric conditions to such an extent as to make desirable a determination of actual candle-power which should be free from outside influence.

25. In preparation for the laboratory test, a lamp mechanism equipped with rotating device was mounted at one end of the mechanical laboratory on a wooden platform and inclosed on three sides, with colored glass placed in an opening on one side. The platform pivoted on a center permitting revolution through an azimuth of 140°, corresponding to the opening usually occupied by the mirror. A scale of degrees read from 0 at the center line (a vertical plane through the axis of the carbons) to 70° on either side. The usual switchboard, rheostat, interrupter, length of arc measurer, and feeding voltage rheostat were installed.

26. The photometer was located at the other end of the mechanical laboratory, distant 60 feet from the arc. Instead of the somewhat inaccurate reducing screens, there was employed a high speed motor carrying a disk with an adjustable sector, so that any degree of opening could be set to obtain the ratio of open to closed space necessary to give the reducing factor desired for the photometer.

27. In taking the measurements, the personnel exercised great care to maintain a constant current and uniform voltage. It was necessary that the carbons burn quietly with an accurately centered arc before taking the readings was begun, and that they be not disturbed during the time of making a run through 120°. Each run took about fifteen minutes to com-

plete, once across. After this run, it was necessary to burn the carbons for about fifteen minutes before they became sufficiently well centered for the next run, for if the carbons started to burn a little off center they could not be disturbed until after the run. If some time before the run was completed, the carbons burnt a little off center, this was corrected before starting again. At each 10 degrees on both sides of the 0 degree, ten readings were taken and the average of these ten readings found. About four runs on a carbon were taken and five carbons were burned for a test, making about 200 readings taken on every 10 degrees and 2400 readings for a test of one pair of carbons. As this number of readings on the photometer was tiring to the eye, and as of the available men there was only one man in the detachment whose eyes were satisfactory for reading the photometer, enough rest had to be given him to prevent injury to his eyes. Photometer readings were taken about seven hours each day for three days a week. All carbons were burned for a period of 1½ hours before any readings were taken, in order to allow the carbon to shape itself for its current and give its best light.

28. The carbons tested included the Siemens, Conradty, and Columbia Nos. 1480, 1481, and 1487, being those that had given the greatest promise in the regular test. An explanation of the method of calculation and detailed data covering these runs will be found in the Appendix, pp. 342 to 369. A comparative statement showing the results of this test appear in the table below.

COMPARATIVE TABLE OF RESULTS IN LABORATORY TEST

Run No. 1–30. Positive carbon, regular. Negative carbon, regular. Distance (D), 60 feet. Ratio of revolving disk, R, 6. Date, January 22–February 5, 1913.

Carbons	Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
Col. 1487	200	65	13000	259002	71300	82000	20.0	.183
Col. 1481	200	65	13000	233212	61200	77600	17.9	.220
Col. 1480	200	65	13000	148952	41000	56200	11.5	.317
Siemens	200	62.5	12500	181622	50000	67000	14.5	.250
radty	200	60	12000	125252	41500	58300	12.5	.290
85 solid	200	60	12000	239052	65750	80000	20.0	.182

29. The foregoing table shows Columbia 1487 to be the best of the cored carbons as regards the amount of available light. The order in which these carbons were rated in regard to the ease of handling was: 1st, Columbia 1487; 2nd, Columbia 1481; 3rd, Columbia 1480; 4th, Siemens; 5th, Conradty;

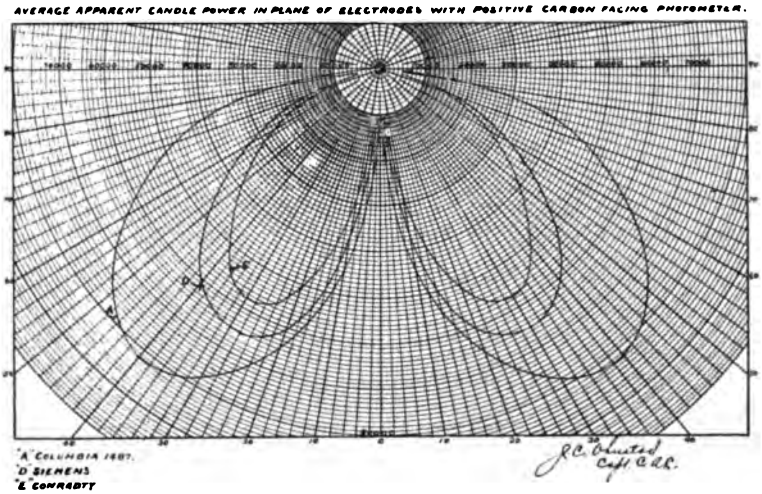


FIG. 4. 1497

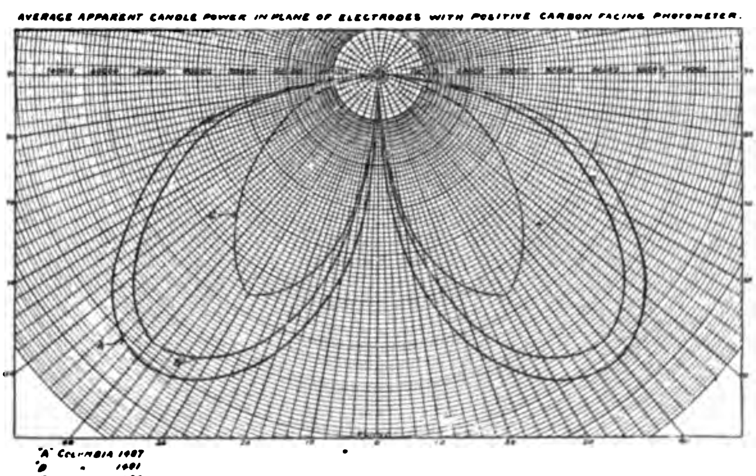


FIG. 5. 1498

and 6th, Columbia 85 (a solid positive). It also developed that the arc remained fairly stable with a rise in voltage up to 75 volts for Columbia 1487, to 70 volts for Columbia 1481, to 65 volts for Siemens and Columbia 1480, and to 60 volts for

Conradty, thus indicating a much greater allowable variation in the arc voltage for Columbia 1487 than for any of the other types.

30. Fig. 4 shows illumination curves for the Columbia 1487, laboratory-made, in comparison with Siemens and Conradty, factory-made types.

31. Fig. 5 shows illumination curves for Columbia 1487, laboratory-made carbons, in comparison with Columbia 1481, laboratory, and 1480, factory-made type, the latter being the one used at present in the service.

32. Comparing the different carbons with Columbia 1480, the following statement shows the increase in per cent of light of different carbons over it:

Columbia, 1487	74 per cent.
Columbia, 1481	56 per cent.
Siemens	26 per cent.
Conradty	9 per cent.

33. These laboratory tests all confirmed the previous conclusion as to the superiority of Columbia 1487 for service use.

AVERAGE APPARENT CANDLE-POWER IN PLANE OF ELECRTODES WITH POSITIVE CARBON FACING PHOTOMETER

Degrees from vertical	Siemens	Conradty	Columbia 1487
0	2160	2160	6500
10	36700	28100	45400
20	60500	49600	67000
30	67000	58300	77800
40	60500	49600	82000
50	47500	38900	75500
60	34000	28100	64500
Mean C. P.	50000	41500	71300

Degrees from Vertical	Columbia 1487	Columbia 1481	Columbia 1480
0	6500	4300	2160
10	45400	34500	30200
20	67000	58000	49600
30	77800	41200	56200
40	82100	77600	49600
50	75500	69000	38800
60	61500	56000	28000
Mean C. P.	71300	64200	41000

SPECIFICATION TEST

34. Having decided upon the best type of carbon, a series of trials was undertaken to secure further improvement, to determine the best conditions under which this carbon could be burned, and to devleop specifications based on actual performances which would insure satisfactory articles upon delivery.

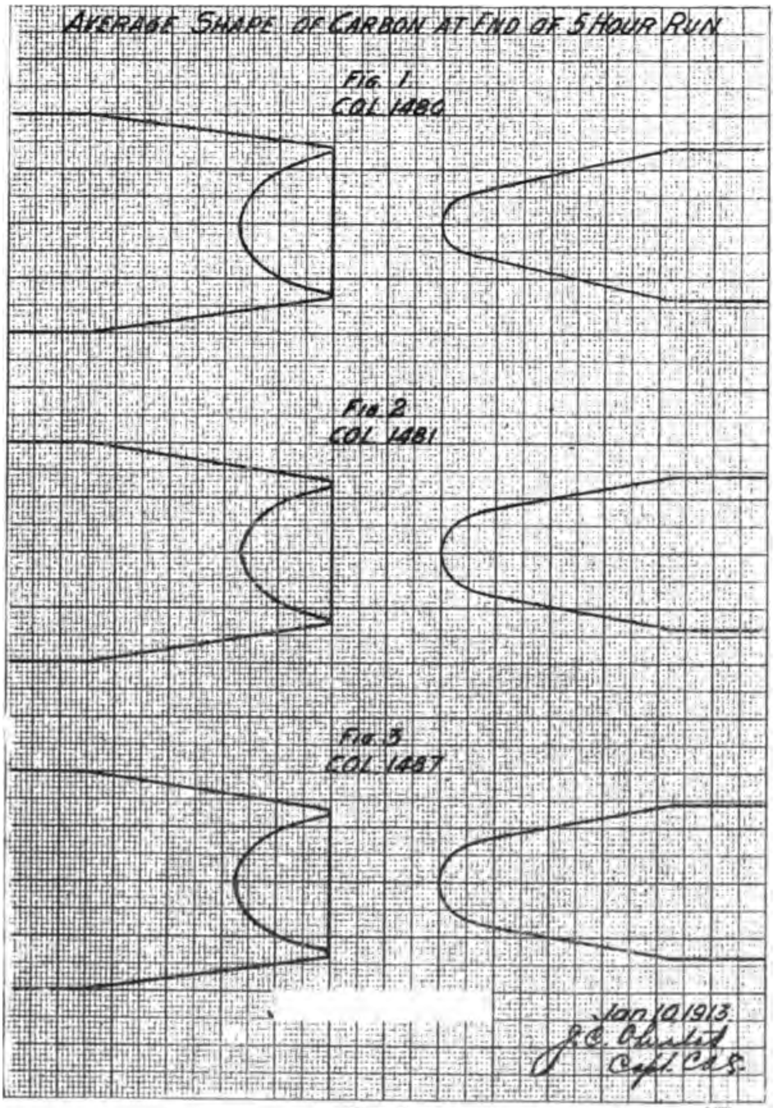


FIG. 6.

SHAPE

35. During the outdoor tests, it was noticed that the carbons did not reach their best light until after the burning

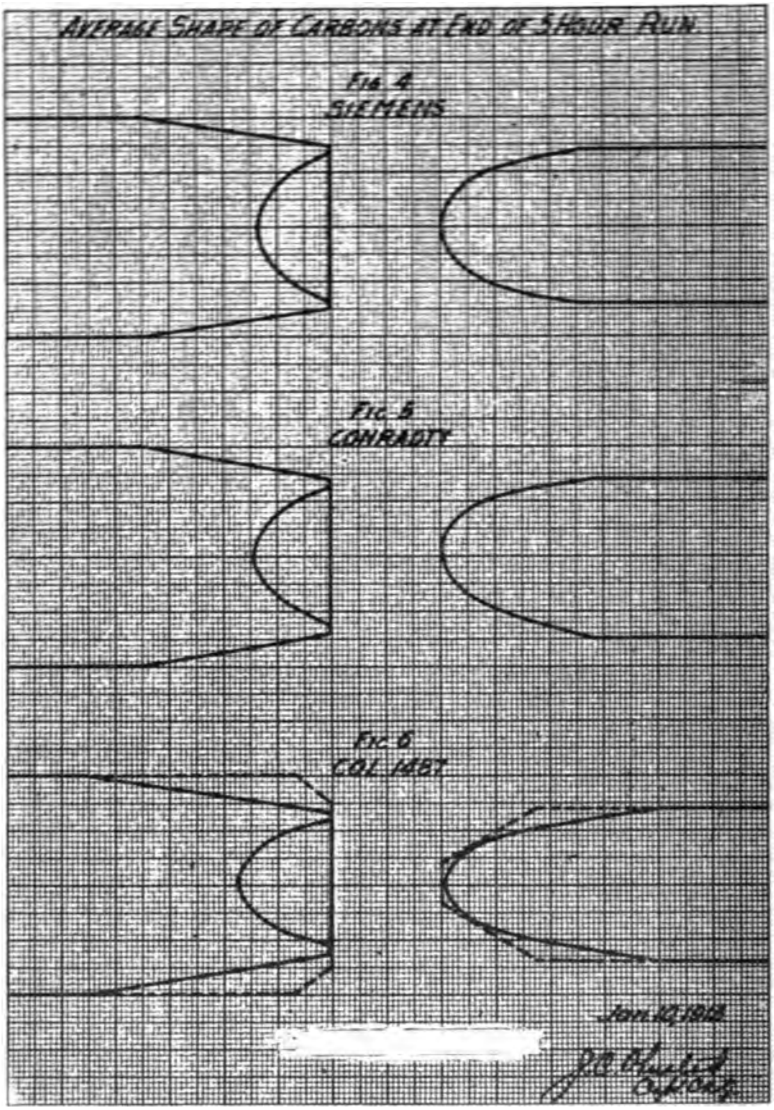


FIG. 7. 1500

point had shaped itself to the current, and that this process required a considerable time. Tactical considerations require that the beam shall go into action at once on command, and

especially that the best light shall be available during the first period of its use when the target is at its maximum distance.

Several pairs of carbons were burned and showed that 1½ hours were required to burn to the shape where the light becomes a maximum with a uniform intensity. The average measurements of the shape of the carbons after burning are given in the first table on page 146. Figs. 6 and 7 show the average shape to which the various carbons burned, and it was believed that the time to attain this shape would be materially reduced by making the original shape of the carbons conform as closely as possible to the average form. This would lengthen the useful life and make the burning characteristics conform to tactical requirements. Orders were placed for positives of the Columbia 1487 type shaped as shown in Fig. 6. (See pp. 370 to 374, Appendix, for data.)

Five pairs of positive carbons, of old and new shapes, were given a competitive photometric test, readings being taken at the beginning, at twenty minutes, and at forty minutes from the start.

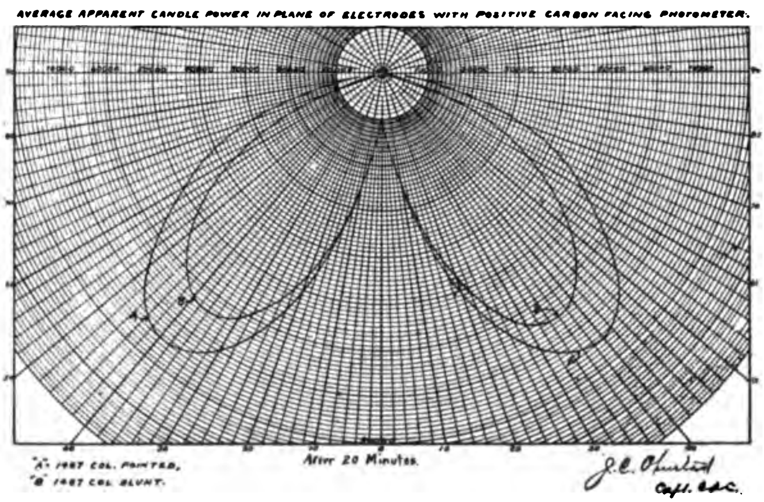
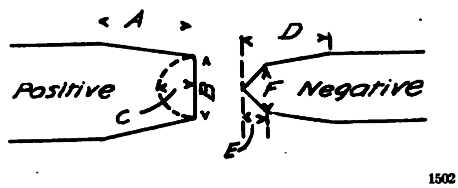


FIG. 8. 1501

36. Fig. 8, plotted from the second table on page 146 shows the illumination of the two types of carbons at twenty minutes after starting, indicating that there is a gain of 18 per cent in total light from using a shaped carbon.



SHAPE OF CARBONS AT END OF RUN

	A in.	B in.	C in.	D in.	E in.	F in.	G f.-c.
Col. 1487	2.35	1.30	.91	2.14	.37	.73	2.1
Conradty	1.76	1.40	.72	1.45	.25	.81	1.6
Siemens	1.80	1.46	.65	1.50	.41	.83	1.5
Col. 1480	2.10	1.38	.95	2.14	.25	.60	.95
Col. 1481	2.43	1.30	.85	2.10	.37	.62	2.5

COLUMBIA 1487 POSITIVE, BLUNT, AND COLUMBIA 1487 POSITIVE, POINTED

Taken 20 minutes after start of burning. Average apparent candle power in plane of electrodes with positive carbon facing photometer.

Degrees from Vertical	Blunt	Pointed
0	2160	2160
10	25900	23800
20	49600	51600
30	64800	69100
40	64800	75500
50	54000	67000
60	36700	49600
M. C. P.	50900	60100

COMPARATIVE TABLE OF 1487 COLUMBIA POSITIVE BLUNT AND POINTED

	Lumens per watt of Columbia 1487 blunt	% of Max. Light	Lumens per watt of Columbia 1487 pointed	% of Max. Light
At beginning	12.0	59	13.6	68
At 20 Min.	15.4	77	18.2	91
At 40 Min.	16.3	82	19.0	95
At 90 Min.	20.0	100	20.0	100

37. Fig. 9, plotted from the third table on page 146 (see pp. 375 to 385, Appendix, for data), shows the comparative value of the light of the two carbons during the first ninety minutes of their burning, indicating a gain for the shaped carbon of 10 per cent at the end of five minutes, 18 per cent at the end of twenty minutes, and 16 per cent at the end of forty minutes.

As the change in shape involved no material increase in cost, but improved the usefulness of the carbons, the new shape was adopted as the standard for future purchase.

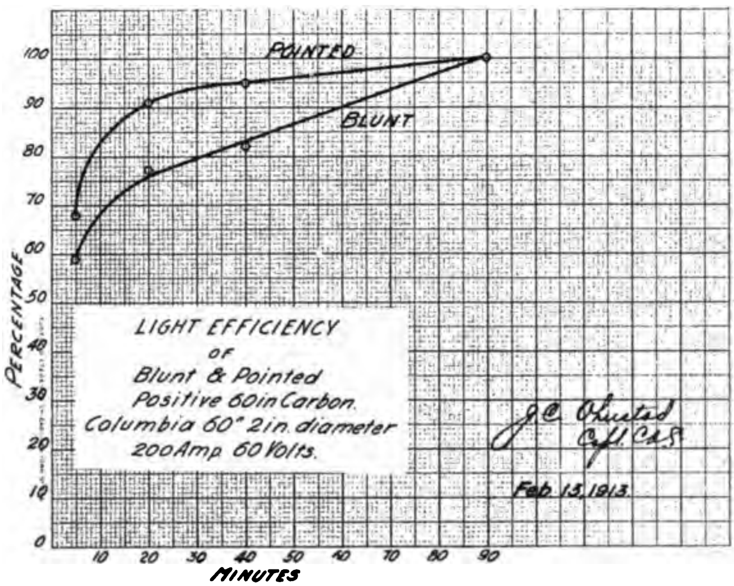


FIG. 9. 1503

CURRENT AND VOLTAGE

38. A series of runs was undertaken with groups of Columbia 1487 carbons in sets of five to observe the effect on the light of varying the current and voltage of the arc. (For data see pp. 386 to 418, Appendix.) Consolidated sheets of the results using 60, 65, and 70 volts appear in the table on page 149.

39. Fig. 10 shows the current curves plotted with current as abscissas and light as ordinates for a constant voltage, indicating that for 65 volts the light varies directly with the current and plots a straight line between values of 180 and 280 ampères. The steadiness of burning and ease of manipulation decreased materially below 180 and above 225 ampères.

The carbons burned very rapidly at the higher currents, decreasing the available life. Between the limits of 180 and 225 ampères the operation was satisfactory aud the existing searchlights can carry the current without any change. 200 ampères was decided upon as the normal current for our service. The test included runs with 60, 65, and 70 volts across the arc. An arc voltage of 65 volts gave the most satisfactory results and was accepted as the normal. The value requires no change in the existing lamp mechanism.

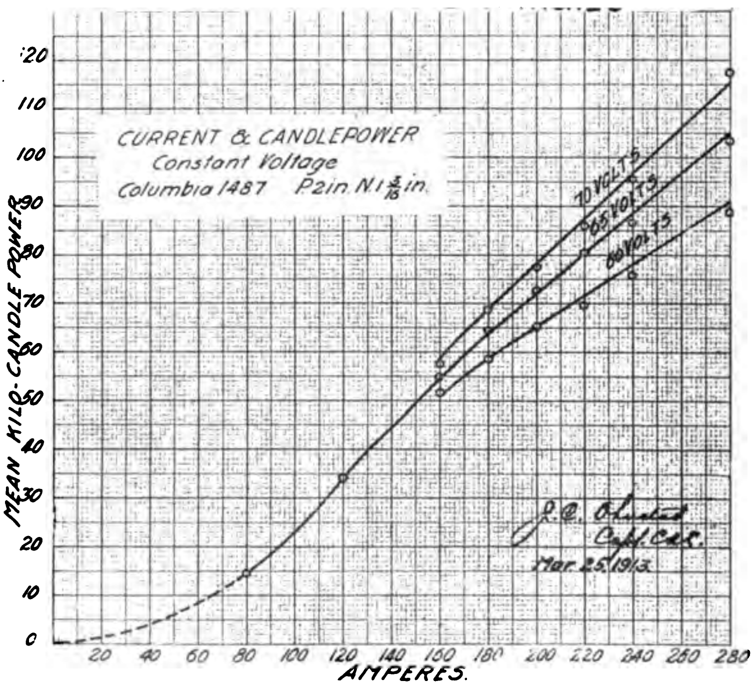


FIG. 10. 1504

DIAMETER OF POSITIVE CARBON

40. In the examination of the current curve (Fig. 10) for 65 volts and variable current, it will be seen that from 180 ampères to 280 ampères the light varies directly as the current and plots a straight line. As the current decreased from 180 ampères the light diminished in a greater degree, showing that something affected the light of the carbon below 180 degrees. It was thought that this may have been due to two causes: first, that as the current decreased, there was less surface volatilized and the outer part of the carbon merely burned and

gave a greater amount of carbon mist which absorbed the light; second, that as the crater area decreased, the effect of the shadow caused by the negative carbon would increase. Experiments made with smaller negatives showed that the latter caused a little difference but accounted for only a very small decrease in light.

TABLE OF RESULTS OF CURRENT AND VOLTAGE TESTS

Runs No. 41-45. Positive Carbon, Columbia 1487 (2-inch). Negative Carbon, Columbia regular. Distance (D), 60 feet. Ratio of revolving disk, R, 6. Date, March 12-25, 1913.

Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
160	60	9600	187470	51700	62500	19.5	.186
180	60	10800	213700	58800	71500	19.7	.184
200	60	12000	236500	65200	78000	19.7	.184
220	60	13200	253190	69700	84000	19.4	.189
240	60	14400	275310	75800	91000	19.2	.190
280	60	16800	323580	89000	116000	19.2	.190
80	65	5200	52690	14500	19400	10.1	.358
120	65	7800	123670	34100	49000	15.9	.228
160	65	10400	199180	55000	67000	19.1	.189
180	65	11700	234010	64500	78000	20.0	.181
200	65	13000	263300	72400	84000	20.2	.180
220	65	14300	292650	80600	99500	20.4	.178
240	65	15600	315050	86800	103800	20.2	.180
280	65	18200	376150	103500	125000	20.6	.76
160	70	11200	207800	57300	73500	18.5	.196
180	70	12600	249650	68700	84500	19.7	.183
200	70	14000	280750	77500	93000	20.0	.181
220	70	15400	312200	86000	103500	20.3	.179
240	70	16800	346300	95500	112000	20.6	.176
280	70	19600	426480	117500	140500	21.8	.167

41. It was thought that a smaller positive carbon should show less carbon mist for the same current and that consequently less light would be absorbed. Two additional sizes of carbon were ordered made of the same composition as Columbia 1487. The sizes were 1¾ inches diameter and 1¼ inches in diameter, the latter size being the same as used in our 36-inch light. The idea of utilizing the 1½-inch to determine this was that data could also be obtained which might be of some use in the operation of the 36-inch light. The results

were quite valuable, as will be shown later. The 1¼-inch carbon was first tested with the same currents as had been used before with the 2-inch; viz., with 65 volts and 80, 120, 160, 200, 240, and 280 ampères. (See pp. 433-443, Appendix, for data.)

42. Fig. 11, plotted from the tables on pages 149 and 151, shows the current curve for the 2-inch carbon with the line straight from 280 ampères to 180 and then falling away. The curve for the 1¼-inch carbon shows a straight line from 280 ampères to 160, then falling away, but not as fast as the curve for the 2-inch.

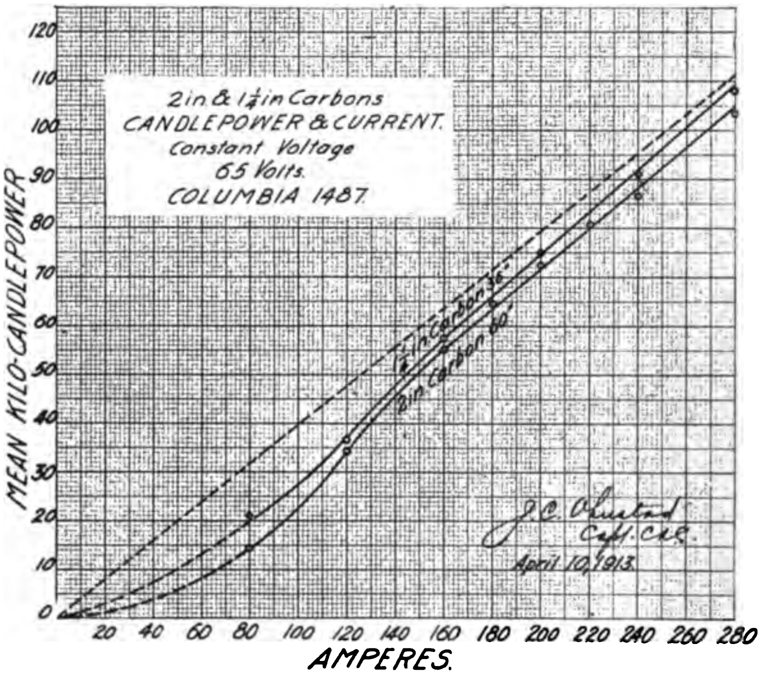


FIG. 11. 1505

The 1¾-inch carbon was also tested and the results would plot slightly above the 2-inch. The 1¼-inch plots above the 2-inch, and the curve below 160 ampères has less curvature than the 2-inch, showing the tendency to straighten as the carbons decrease in size to meet certain currents. The curves show that as the carbons are decreased in size the curve becomes nearer and nearer a straight line and with slightly increasing light, and, if we could conceive of a pair of carbons of no dimension, the curve would be a straight line and be approximately the

dotted line shown in Fig. 11. From the above it is seen that, considering light alone, the smaller the carbon, the better the light for the same current. There are other considerations which would govern in determining what size of carbon to use. (See pp. 419 to 449, Appendix, for data.)

TABLE OF RESULTS OF DIAMETER TESTS

(See also table of results of current and voltage tests, page 149.)

Runs No. 46-50. Positive Carbon, Columbia 1487 (1¾-inch). Negative Carbon, regular. Distance (D), 60 feet. Ratio of revolving disk, R, 6. Date, March 25-27, 1913.

Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per per Watt	Watts per Mean C.-P.
80	65	5200	56120	15500	19500	10.8	.335
120	65	7800	129560	35700	47500	16.6	.218
160	65	10400	198910	45000	65000	19.1	.189
180	65	11700	235350	64800	80000	20.1	.181
200	65	13000	262900	72300	86500	20.2	.180
220	65	14300	293230	80700	97200	20.4	.178
240	65	15600	320150	88200	108000	20.4	.178
280	65	18200	377700	104000	123000	20.7	.175

Runs No. 56-60. Positive Carbon, Columbia 1474 (1¼-inch) 36-inch. Negative Carbon, regular 36-inch. Distance (D), 60 feet. Ratio of revolving disk, R, 6. Date, April 8-9, 1913.

Amps.	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
80	65	5200	96640	21000	2600	14.7	.247
120	65	7800	134360	36900	47500	17.2	.211
160	65	10400	208350	57500	69000	20.0	.181
200	65	13000	272250	75000	89000	20.9	.174
240	65	15600	330950	91000	106000	21.2	.172
280	65	18200	392750	108000	130000	21.5	.168

43. Fig. 12 shows the efficiency curve with mean candle-powers as ordinates and kilowatts as abscissas. This shows that for the currents with which we are concerned (160 to 280 ampères) the light increases directly with the wattage. How far this would hold above 280 ampères cannot be stated; but if the carbons were increased in diameter so as to carry the higher currents, the curve should become a straight line; *i.e.*, the light should vary directly as the watts used in the arc.

This shows that, considering light alone, the smaller the carbon, the better the light for the same wattage used in the arc.

44. The results of tests of carbons of different diameters showed that none possessed any material advantages over the standard 2-inch size; therefore, as any change would require a modification in all the carbon-holders in service, a diameter of 2-inches for the positive carbon was accepted as standard.

45. Fig. 13 is a full size drawing in cross-section of the three different size carbons burned.

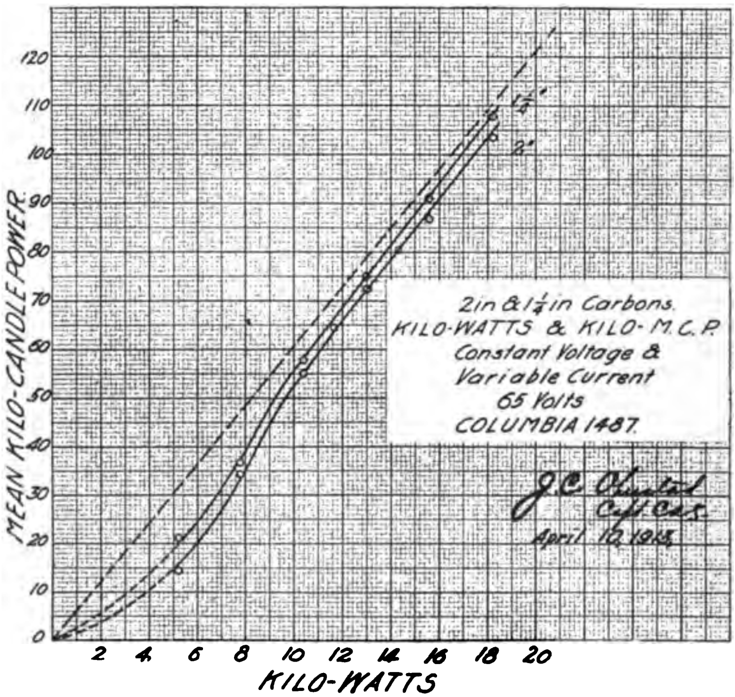


FIG. 12. 1506

46. Fig. 14 shows current curves for the three different diameters of carbons plotted with mean candle-powers as ordinates and areas of carbon in square inches as abscissas. It is seen that there is an increase in the amount of light per unit of area the smaller the carbon. The dotted lines are based on the dotted lines shown in Fig. 11.

47. Fig. 15 gives curves showing the effect of decreasing the voltage but keeping the current constant at 200 ampères, from which it again appears that the light decreases directly

as the wattage, until a point is reached where the carbon mist due to imperfect volatilization absorbs a portion of the light.

Runs No. 50-51. Positive Carbon, Columbia 1487 (2-inch). Negative Carbon, regular. Distance (D) 60 feet. Ratio of revolving disk, R, 6. Date, March 27-April 1, 1913.

Amps.	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
200	30	6000	50740	14000	21600	8.4	.430
200	40	8000	133430	36800	45500	16.6	.220
200	50	10000	198800	55000	67000	19.9	.182

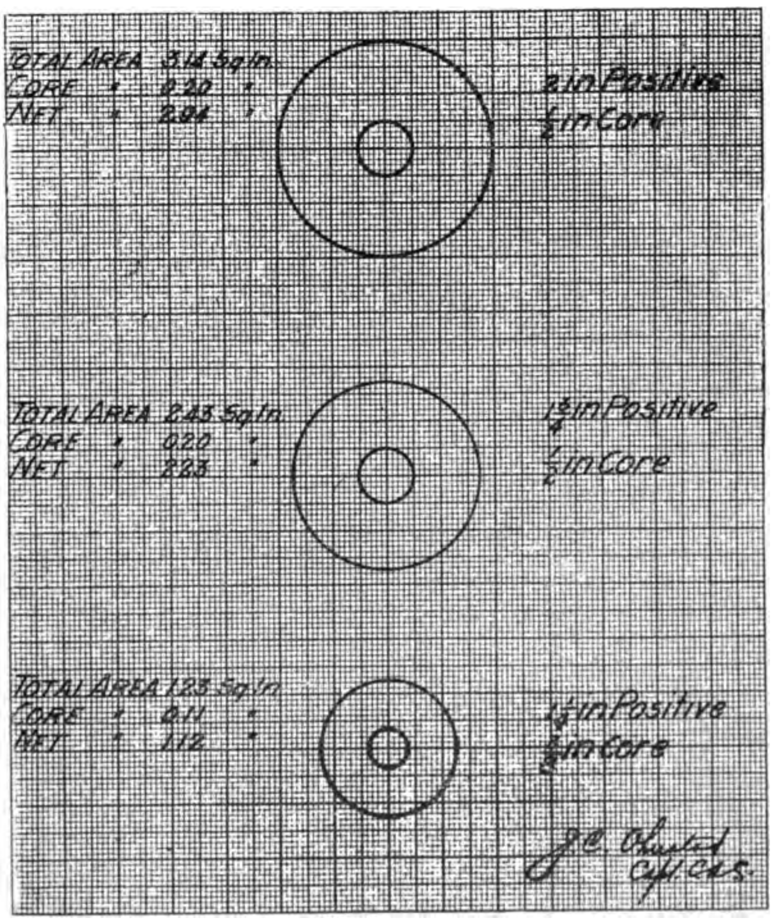


Fig. 13. 1507

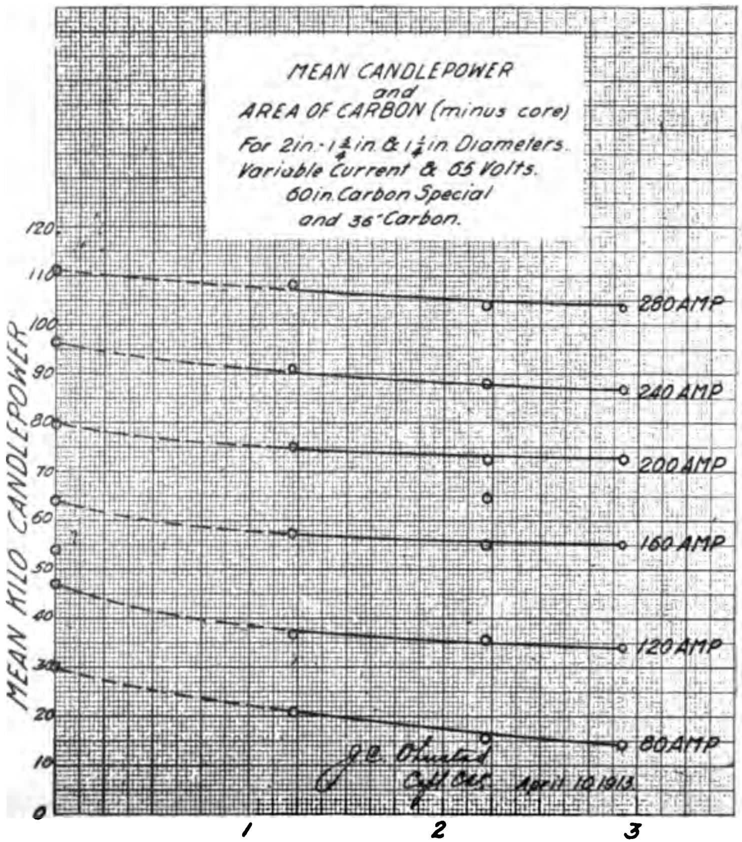


Fig. 14.

1508

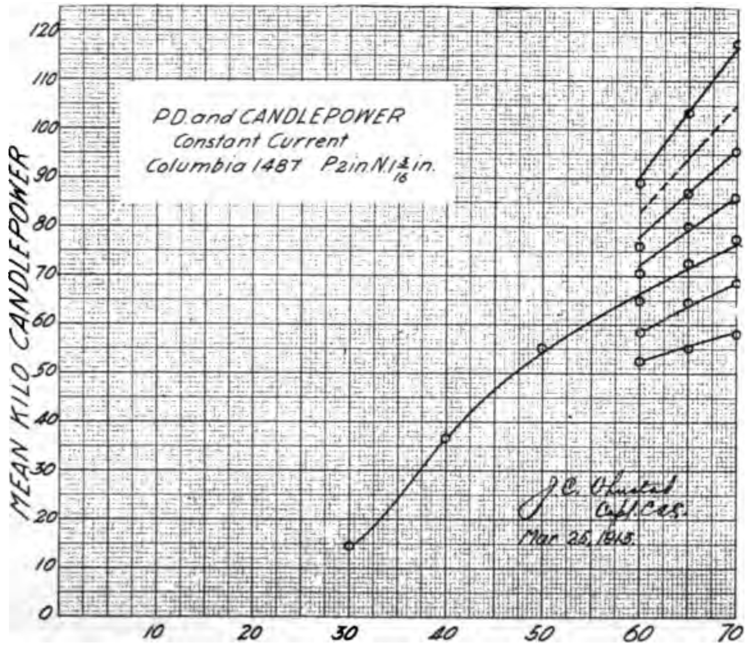


Fig. 15.

1500

LENGTH OF ARC

48. The previous tests had shown that the length of arc exercised a very great influence upon the amount of light emitted from the arc, so a series of tests were undertaken to obtain values over a considerable range of lengths for a current of 200 ampères and 65 volts. A good deal of manipulation of the line rehostat and voltage was necessary to be able to vary the length of arc while keeping the current and voltage constant.

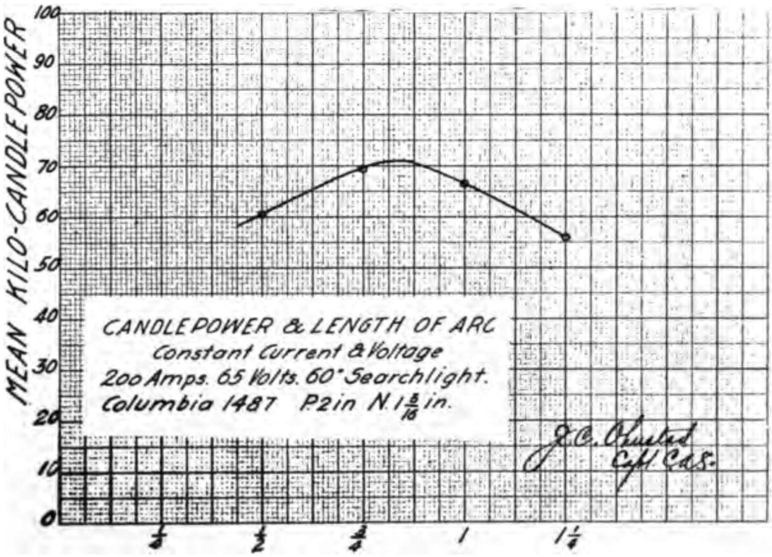


FIG. 16. 1510

LENGTH OF ARC TEST

Runs No. 52-55. Positive Carbon, Columbia 1487 (2-inch). Negative Carbon, regular. Distance (D), 60. Ratio oJ revolving disk, R, 6. Date, April 7-8, 1913.

Length of Arc	Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
1¼ in..	200	65	13000	202250	55700	71500	15.6	.231
1 in..	200	65	13000	241550	66500	84000	18.6	.196
¾ in..	200	65	13000	251950	69500	86500	19.4	.187
¼ in..	200	65	13000	220350	60500	80000	17.0	.215

Runs No. 61-65. Positive Carbon, Columbia 1474 (1¼-inch). Negative Carbon, 36-inch regular. Distance (D), 60 feet. Ratio of revolving disk, R, 6. Date, April 9-14, 1913.

Length of Arc	Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
½ in..	150	65	9750	180480	49700	60000	18.5	.196
¾ in..	150	65	9750	195050	53600	67000	20.1	.181
1 in..	150	65	9750	173610	47200	60000	17.8	.206
1¼ in..	150	65	9750	165510	45500	60000	17.0	.214

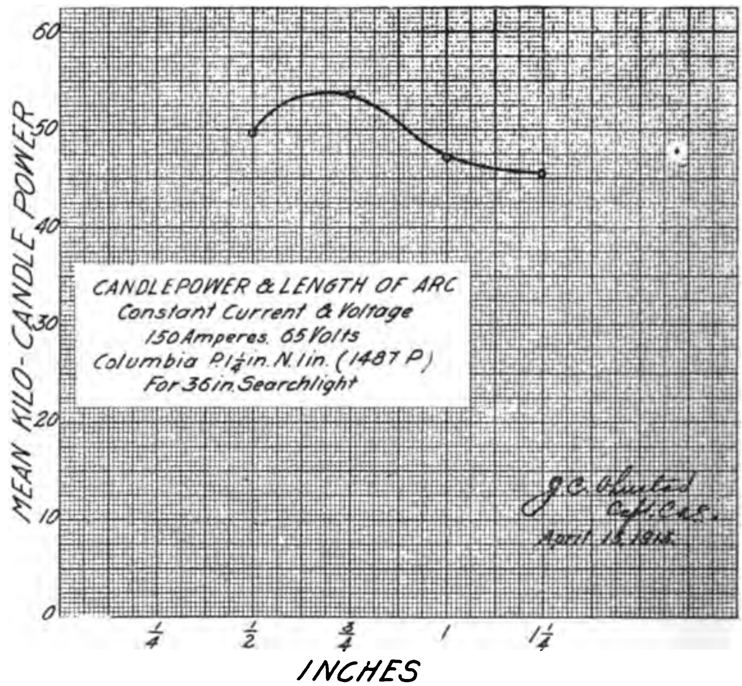


FIG. 17. 1511

49. Fig. 16 shows the length-of-arc curve plotted with candle-powers as ordinates and lengths of arc as abscissas, from which it is seen that the light increases from 61,000 candle-power at ½ inch to a maximum of 71,000 candle-power at 0.8 of an inch, and then falls off to 55,700 candle-power at 1¼ inches through a rather regular curve. There is a

difference of 27 per cent in the amount of light, resulting merely from a change in the length of the arc. This is a very important difference and one which must be considered in the operation of the light. The best results will be obtained using an arc length of 0.8 of an inch. (See pp. 450 to 455, Appendix, for data.)

50. Fig 17 gives the length of arc curve for the 36-inch carbon at 150 ampères and 65 volts between the same limits of ½ inch and 1¼ inches. This shows that about ¾ inch is the best length of arc for the 36-inch carbon. (See pp. 456 to 463, Appendix, for data.)

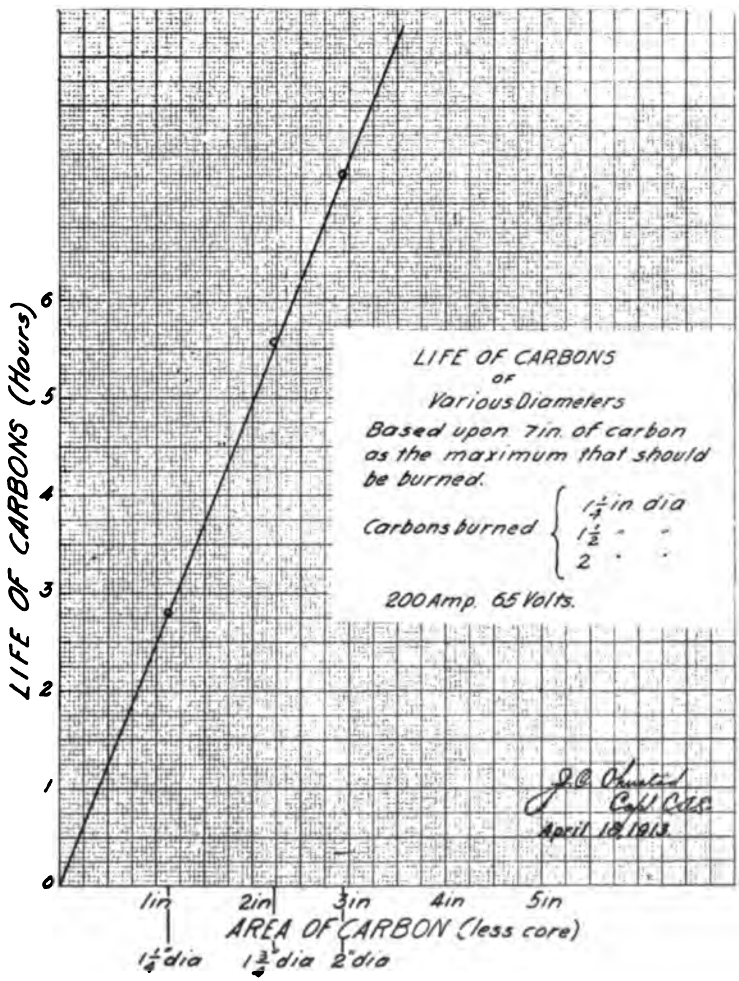


Fig. 18.

1512

LIFE OF THE CARBON

51. The life of the carbon is a very important matter, since it requires about three quarters of an hour to remove a burned-out carbon, to insert a new pair, and to burn this new pair long enough to acquire the best shape. The life should be such as to necessitate the minimum number of such interruptions, and it will be a function of the length of the carbon, arc current, and composition of the shell and core. The heat evolved in burning requires a focal distance equal to that in the service searchlight, unless artificial means of cooling are employed, and larger carbons are impracticable with the present carriage and focal length.

52. Fig. 18 shows the life of various sizes of carbons based on burning seven inches of positive carbon with 200 ampères and 65 volts. Experiments were made on carbons of 1¼-inch 1¾-inch, and 2-inch diameter to determine their rate of burning. The results are tabulated below:

Size of carbon	Area (less core)	Rate per hour	Cu. in. per hr.	Life of carbon
1¼-inch	1.12 sq. inch	2.5 inch	2.8	2.8 hours
1¾-inch	1.23 sq. inch	1.25 inch	2.8	2.6 hours
2-inch	2.94 sq. inch	.96 inch	2.8	7.3 hours

53. From this table it appears that 2.8 cubic inches per hour of carbon were burned, regardless of the size of carbon. This gives 7.3 hours as the available life of the 1487 2-inch carbon, which is a little longer than the life of other types of carbons. To provide against variation, an available life of six hours has been accepted as the standard requirement. This will necessitate but one interruption during one night.

CRACKING

54. An investigation was undertaken to discover why carbons cracked during burning. It has been customary to pack carbons in air-tight cans, and the cracking has usually been attributed to moisture absorbed after the cans are opened. A carbon from a freshly opened can was found to contain .06 per cent of moisture, and one exposed to the open air for ten days contained .12 per cent. No attempt is made at the factory to dry the carbons before packing, consequently the percentage of moisture will vary between wide limits.

55. A carbon was placed in damp cloths until it had absorbed 1.06 per cent of moisture. It was then transferred to

the carbon holders and heated with a 75-ampère current until dry.

56. Fig. 19 shows the drying curve. The amount of moisture that a carbon will absorb by being left exposed to the air is about one sixth of one per cent, and the carbon can be dried by heating with the 75-ampère current from the occulting switch for fifteen minutes.

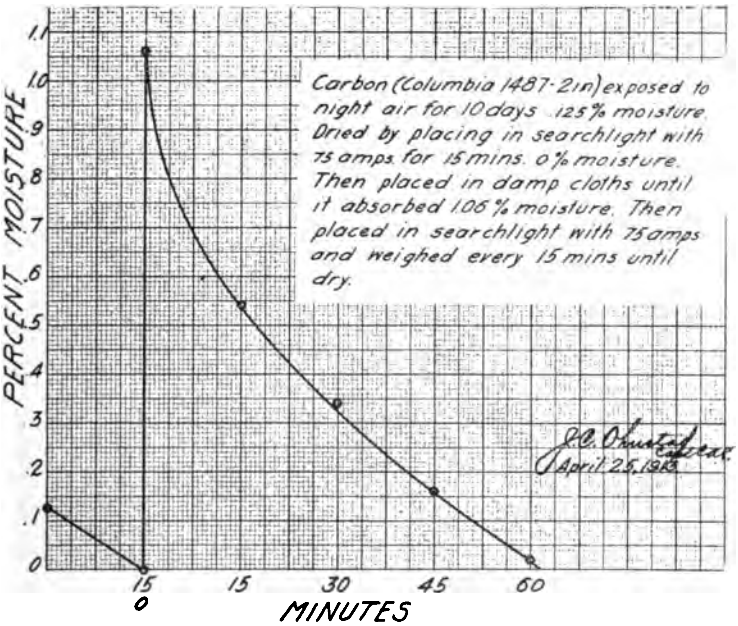


FIG. 19. 1513

Moisture Test

1487 Columbia (pointed):

Exposed to night air for 10 days.........Weight	16593	grams,	125%
Dried at 75 amp. in searchlight for 15 minutes...	16572	"	0%
Dried at 75 amp. in searchlight for 30 miuntes...	16572	"	0%
Moistened in cloth..........................	16748	"	1.06%
Dried at 75 amp. in searchlight for 15 minutes ...	16661	"	.54%
Dried at 75 amp. in searchlight for 30 minutes ...	16629	"	.34%
Dried at 75 amp. in searchlight for 45 minutes ...	16599	"	.16%
Dried at 75 amp. in searchlight for 60 miuntes ...	16575	"	.02%

A 1480 Columbia (blunt) was taken out of a can of carbons which had not previously been opened and was weighed:

Weight of 1480 Columbia taken from can.......	16998	grams,	.06%
Dried at 75 amp. in searchlight for 15 minutes....	16978	"	0%
Dried at 75 amp. in searchlight for 30 minutes....	16978	"	0%

57. Two carbons were wrapped in damp cloths until one had absorbed one per cent and the other two and a half per cent of moisture, when they were placed in a searchlight and burned without any heating whatever. Fig. 20 is a drawing of the carbon with 2.5 per cent moisture, showing the cracks. At the end of fifteen minutes a piece had broken off. Fig 21 shows the carbon containing 1 per cent moisture, which after thirty minutes burning developed cracks that caused pieces to fall out.

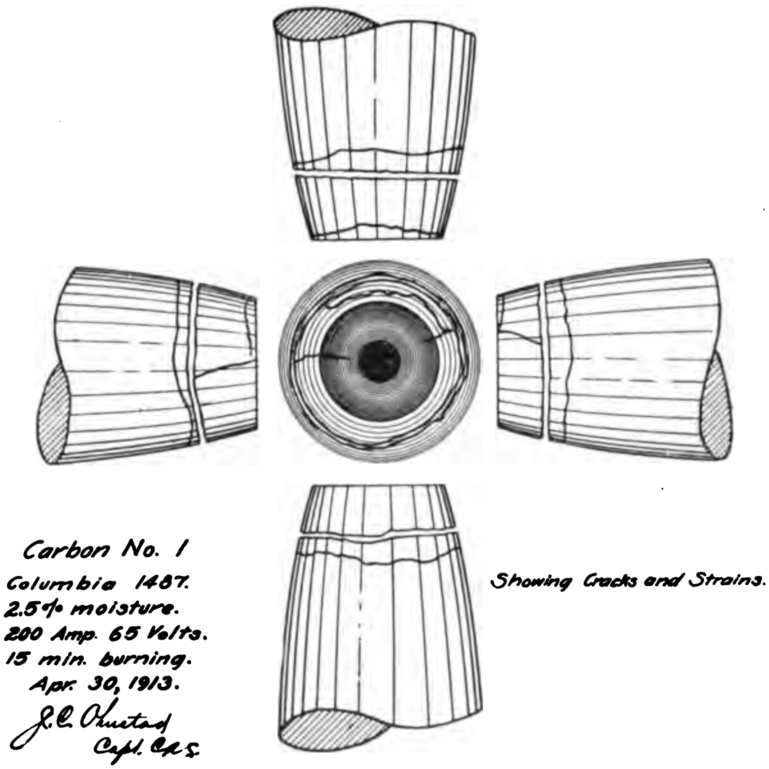


FIG. 20. 1514

58. Another carbon was immersed in water until it had absorbed $4\frac{1}{2}$ per cent of moisture, when it was placed in the searchlight and heated with a current of 75 ampères for fifteen minutes, after which it was quickly removed, weighed, found to contain 3 per cent of moisture, immediately replaced, while still hot, and burned with a current of 200 ampères. The carbon burned without developing cracks at any time during its life. This indicates that the cracking does not result entirely

from the presence of moisture. A dry but cold carbon was placed in the light and a current of 200 ampères thrown on, with the result that cracks developed.

59. From the above series of experiments it was concluded that the mere presence of moisture in the carbon does not cause cracking, but that the unequal heating of the different parts of the carbon due to sudden change in temperature resulting from

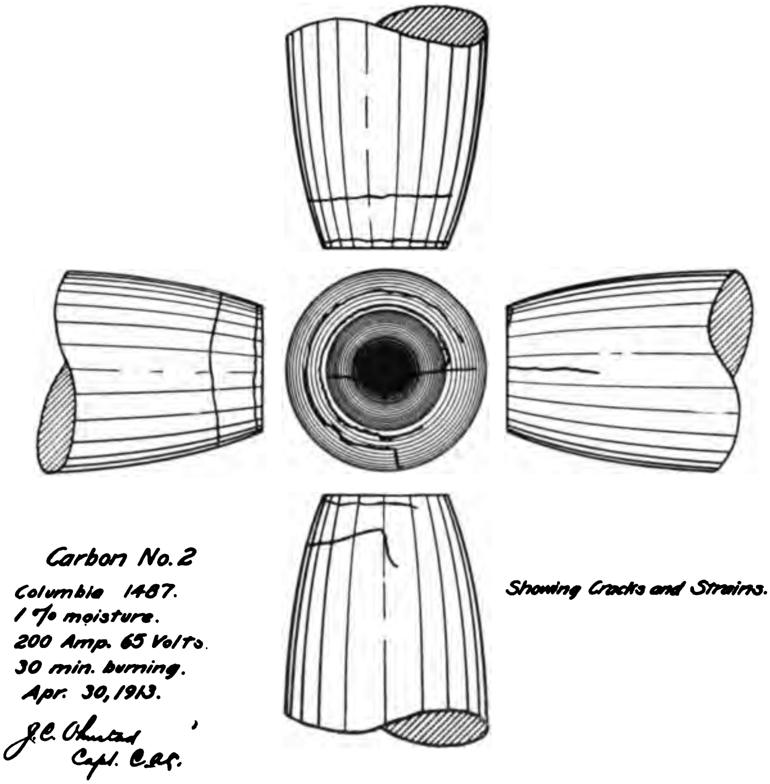
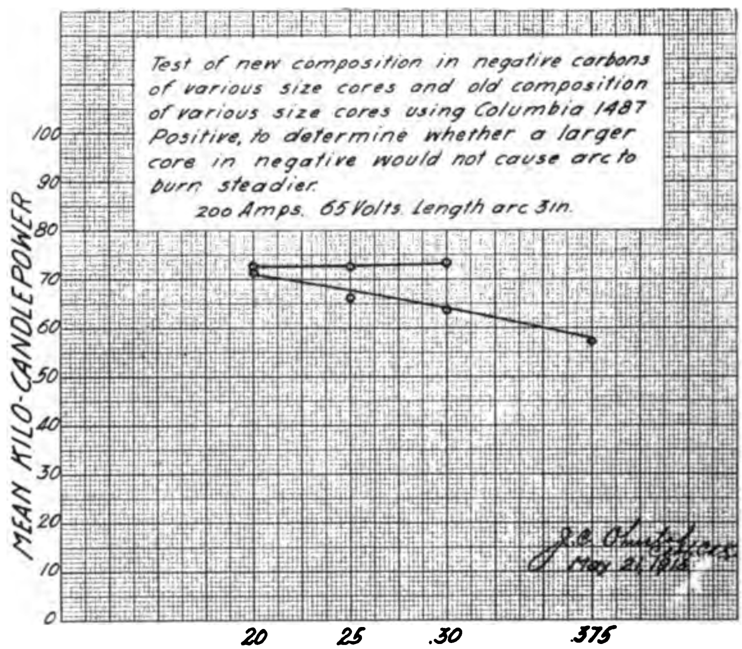


FIG. 21. 1515

throwing on the full load current is the most important cause. Cracking can be almost entirely eliminated by feeding the carbons together till they meet and then heating them with a 75-ampère current for 15 minutes. This brings the carbon up gradually to a heated condition from a cold state, thus preventing the development of internal strains from the unequal heating. It also dries out slowly any moisture that may be present.

CORE

60. An improvement having been secured in the positive carbon, experiments were conducted looking to a better negative carbon. As the function of the negative carbon is to support the arc and conduct the current, the investigation had in view greater steadiness in burning, rather than an increase of light. Carbons were ordered having various diameter of core and different core compositions. Fig. 22 shows that as the diameter of the core increases, using the old core composition, the candle-power decreases, due to the absorption



Diameter of Core in Inches

FIG. 22. 1516

of light by the gases evolved from the core material. Ease of manipulation and steadiness of burning increased with the diameter of the core, but at the greater diameters a tendency to form a crater developed. The cores filled with the new composition showed practically no falling off in light with the increase in diameter. There was the same increased ease of manipulation and steadiness of burning with the same tendency to crater in diameters greater than one fourth of an inch.

61. It was decided that the core of the negative carbon

having a diameter of one fourth of an inch and filled with the same composition as the positive carbon, was the most satisfactory. (See pp. 464 to 479, Appendix, for data.)

62. Hissing of the arc results, as a rule, either from the separation of the core material from the shell or from the failure of the core composition to completely fill the core cavity. In connection with the development of the new type of carbons, it became necessary to devise a better method of inserting the core composition so as to completely fill the core cavity and to prevent its separation from the shell. It is thought that the final result will be a marked improvement over previous methods and that it should give a much more uniform burning at the arc.

TESTS OF DIAMETER OF CORE

Runs No. 66-73. Positive Carbon, Columbia 1487. Negative Carbon, Columbia 1601 Core .375, 1602 Core .30, 1603 Core .25. Distance (D), 60. Ratio of revolving disk, R,6. Date, April 15-23, 1913.

Core Diameter	Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
.375	200	65	13000	208200	57200	73500	16.0	.228
.30	200	65	13000	231050	36700	75500	17.8	.204
.25	200	65	13000	239200	66000	78000	18.1	.200
.20	200	65	13000	259000	71300	82000	20.0	.183

Runs No. 75-85. Positive Carbon, Columbia 1487. Negative Carbon, Columbia 1637 .2-in. core, 1638 .25-in. core,1639 .30-in. core. Distance (D), 60. Ratio of revolving disk, R, 6. Date, May 8-17, 1913.

Core Diameter	Ampères	Volts	Watts	Lumens	Mean Candle-Power	Maximum Candle-Power	Lumens per Watt	Watt per Mean C.-P.
.30	200	65	13000	266150	73200	88500	20.4	.178
.25	200	65	13000	262700	72500	90500	20.2	.179
.20	200	65	13000	264510	72700	86500	20.3	.179

63. Tests were also conducted with various sized cores for the positive carbons, but the maximum light resulted with a half-inch core. Larger diameters led to the arc stream traveling around the sides of the core, giving irregular illumination; while with smaller diameters the arc stream would jump out of the center of the crater to the edge of the shell, giving irregular burning.

Specification

64. As a result of the previous tests and a study of the various plates giving the average performance to be expected, specifications were drawn up and a requisition forwarded on May 13, 1913, for 1000 pairs of 60-inch carbons to be made up under factory conditions. The tests on the Columbia carbons had been conducted on samples fabricated in the engineering laboratory under the supervision of the engineering staff, and it was desired to determine how nearly the laboratory results could be duplicated when the carbons were produced on a commercial basis, before drawing up the final specifications.

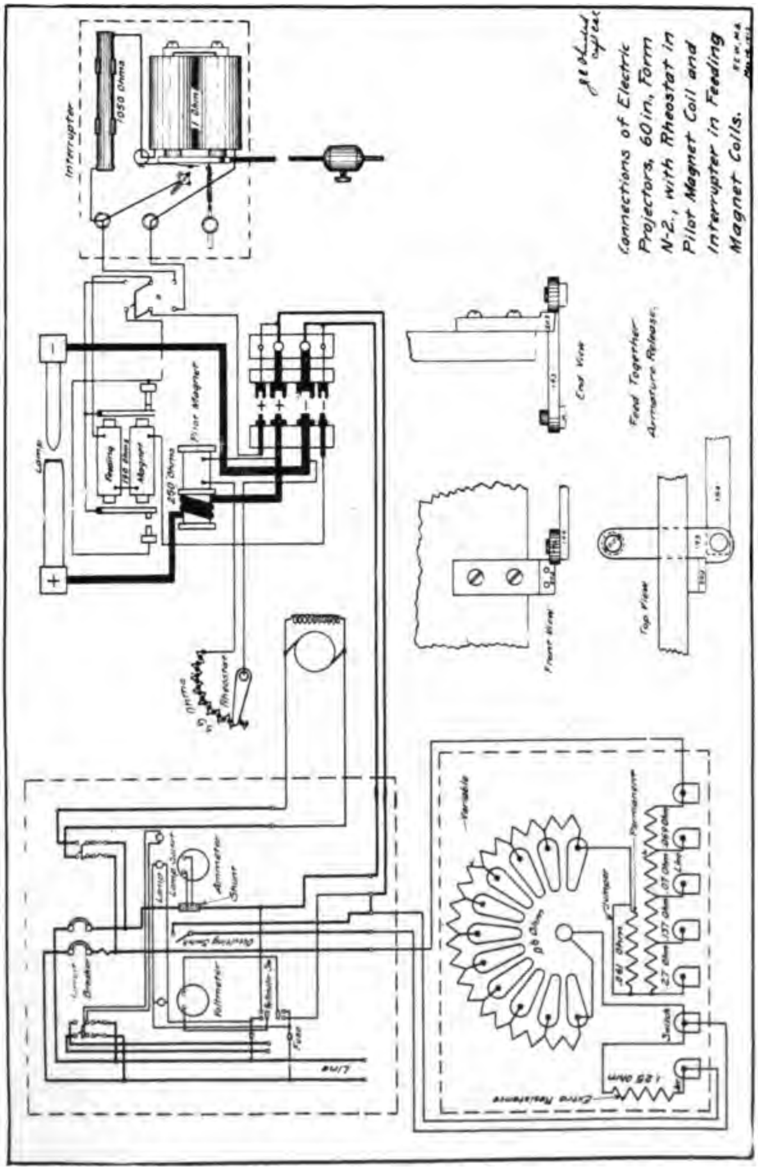
Searchlight Devices

PILOT MAGNET COIL RHEOSTAT

65. Under the head of adjustment, page 16, Instruction Book, No. 8413, as issued by the General Electric Company, the following statement appears:

> Each lamp is carefully tested and adjusted before leaving the factory and no change should be made in the adjustment unless the lamp fails to maintain usual voltage across the arc, when 175 ampères are flowing through the carbons. In this connection, it should be noted that, with a given arc current, the voltage which the lamp will automatically maintain across the arc is less upon first starting than it is after the temperature of the pilot rheostat has increased. This is due to the fact that the resistance of the pilot magnet, upon first starting the lamp, is less than it is after the current has passed for some time through the magnet, and consequently, when starting, a lower voltage is required to produce through the pilot magnet a flow sufficient to attract its armature.

66. The rise in feeding voltage amounts to as much as ten volts, causing irregular burning when the searchlight is in operation for long periods. By placing a rehostat of about fifty ohms resistance and one ampère carrying capacity in series with the pilot magnet coil, the change in resistance in the pilot coil and consequently the change in the current through that coil, can be easily regulated, so that the voltage


Connections of Electric Projectors, 60 in. Form N-2., with Rheostat in Pilot Magnet Coil and Interrupter in Feeding Magnet Coils.
Interrupter
1050 Ohms
1 Ohm
Lamp
Feeding
Magnet
Pilot Magnet
250 Ohms
Rheostat
End View
Feed Together
Armature Release.
Front View
Top View
Variable
Permanent
Jumper
88 Ohms
Switch
Extra Resistance
1.25 Ohm
Current
Breaker
Voltmeter
Ammeter
Shunt
Fuse
Line

1517

FIG. 23.

across the arc can be maintained constant at all times. Starting with the feeding magnet coil, the feeding voltage is noted, and, by means of the rheostat, the feed-together armature can be made to operate on the desired voltage. As the coil warms up or as other changes produce changes in voltage, the rheostat resistance is regulated so as to maintain a constant resistance in the feeding magnet circuit, and the voltage at which the feed-together armature will operate can be controlled within a volt or two. The circuits are shown in Fig. 23.

67. It is recommended that all searchlights be provided with such a rehostat. The material can usually be found already available at posts; if not, it will cost very little to purchase, and the labor of installation can be performed by enlisted specialists. This device was found necessary and was used during the entire test.

INTERRUPTER

68. Fig. 23 shows the interrupter placed in the feeding magnet circuit. The necessity for this is as follows: In the feed-together armature release (shown in Fig. 24) the part numbered 203 is pressed against 193, and, when arm 194 is attracted by the magnet of the pilot coil, a friction of position has to be overcome in releasing 193 from 203. The additional voltage necessary to cause the armature to release, varies irregularly from one to five volts, and, consequently, it is difficult to have the armature operate always at the same voltage. It may feed too much or too little, causing irregular burning at the arc. If the part 203 is kept vibrating, there will be little friction of position between 203 and 193, and the armature release will operate on a constant voltage of about two volts. This is also true of the feed-apart armature.

69. The interrupter has an additional value in that it can be regulated by changing the length of pendulum so as to vary the rate of feed of the carbons. A switch is used to throw the interrupter of the vibrator into the circuit. It may be necessary to have the carbons fed apart rapidly and then, after the arc is struck, to throw in the interrupter. Sometimes it is necessary to cut both out for a short period, and this can be done by opening the switch; as for example, if any part of the feeding device should become loosened and it is necessary to adjust it. Also, by means of this switch, the feed-together release can be controlled by opening and closing the switch,

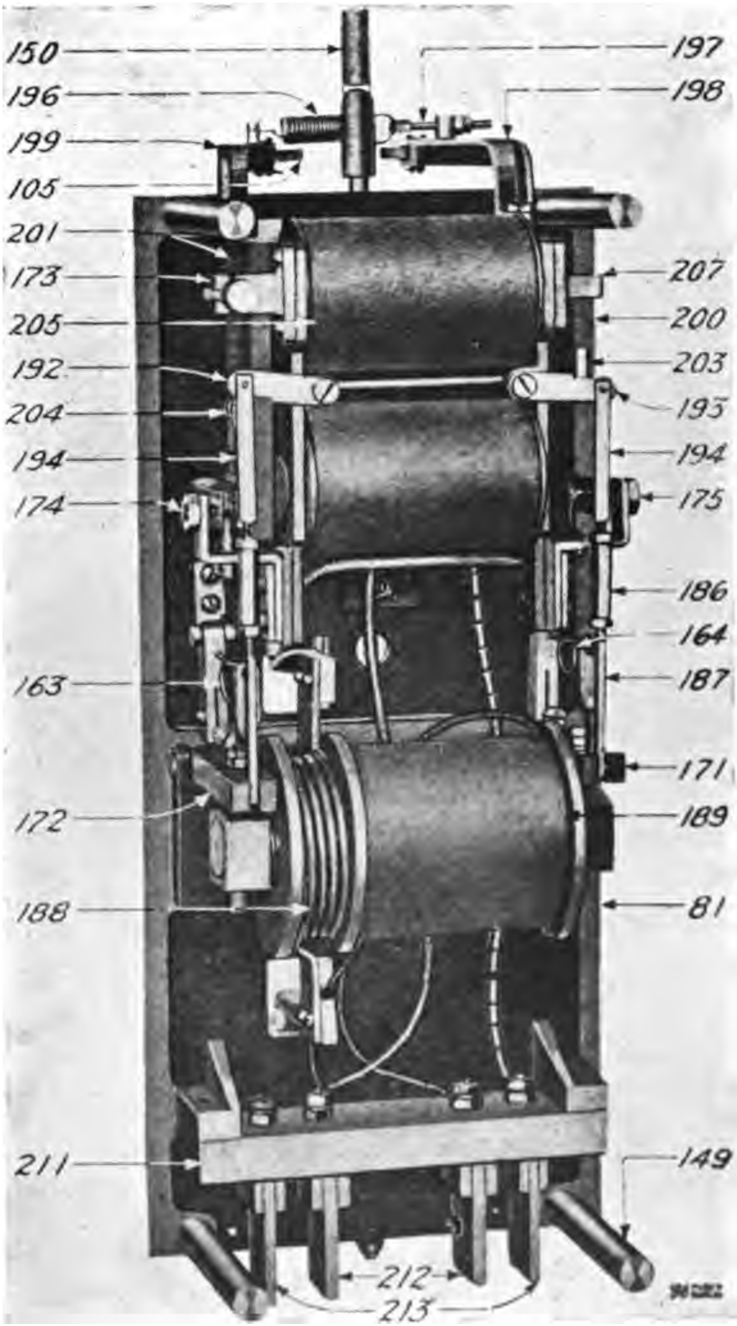


Fig. 21.
Lower Side of Lamp

making the armature operate at the will of the operator. This is sometimes necessary in order to maintain the desired length of arc. The interrupter device was first suggested and tried by two officers of the advanced class, Captains J. B. Taylor and F. Q. C. Gardner, Coast Artillery Corps.

70. An interrupter should be supplied to all 60-inch searchlights. No entirely satisfactory device has been developed as yet for service use: so it is recommended that the subject be taken up in connection with the development of a new lamp mechanism.

LAMP MECHANISM

71. The present standard type lamp mechanism is unsatisfactory in that the feeding voltage rises with the continued use of the light, that the pilot magnet device feeds irregularly, and that the type is a step-by-step mechanism. All the above defects cause irregular burning, and it is believed that a more satisfactory mechanism can be developed. The addition of the feeding magnet rheostat and the interrupter has materially improved the operation. Based on the performance of a lamp mechanism of a motor feed type for the 36-inch searchlight, a requisition was forwarded on January 22, 1913, for a similar lamp mechanism in the 60-inch size, and this device was delivered on December 12, 1913. It is recommended that the test of this new lamp mechanism be undertaken during the coming year in connection with similar developments.

SHUTTER

72. One of the tactical requirements of a searchlight is that the beam shall be available at command, and that the intensity of the beam shall be at its maximum during the first few minutes of its use. The range to the approaching vessel will be a maximum when the vessel is first discovered and will gradually decrease. When the arc is struck, it requires a certain length of time for the beam to attain its maximum value, so that the light is least efficient when first put into use and gradually increases in efficiency with the passage of time.

73. The tests conducted to determine the best shape for the carbon point had for their object a reduction in the length of time required for the proper shape and maximum brilliancy to be attained. While this length of time was materially reduced, the beam still does not reach its maximum until the target has had time to run all the way in from the range at

which it could be discovered. The occulting switch decreases the time required to restore the beam, but is entirely unsatisfactory as a solution. It therefore follows that the arc must be kept burning continuously, so that at the command, "In action," the beam may be instantly brought into use at its maximum efficiency. The use of a shutter becomes imperative.

74. The requirements for a searchlight shutter are:

a. It should be light-tight to the extent that the position of the searchlight cannot be located with a pair of field glasses at 1500 yards, when the shutter is closed.

b. The shutter should be designed to operate quickly under all conditions of wind and weather without the assistance of additional personnel.

c. The design should be compact without projecting parts which would cause difficulty of operation in high winds, heavy rains, or snow storms.

d. It should not reduce the diameter of the beam.

e. It should leave the beam free of all obstructions.

f. It should not be so heavy as to unbalance the light whether opened or closed, nor make it difficult to traverse or elevate.

g. The shutter should not project to the front so as to require an enlargement of the searchlight shelter.

h. The shutter should be so designed as to permit the front door to be opened easily.

i. The shutter should be rugged in design and capable of standing hard usage.

j. The material should be such as not to require frequent renewals.

k. The price should be reasonable, and in no case exceed ten per cent of the cost of the light.

75. It is recommended that shutters be provided for searchlights of all sizes and that experimental work be undertaken to develop a satisfactory type.

OCCULTING SWITCH AND RHEOSTAT

76. The occulting switch and rehostat were installed on the present type searchlights so that the carbons could be kept hot with a 75-ampère current when the light was not in use, with the object of putting the beam into action at once by merely closing the switch. In practical operation, it requires from five to ten minutes for the crater to adapt itself to the change in current from 75 to 200 ampères, so the solution

is unsatisfactory. With the installation of a shutter, this device becomes useless for the purpose for which originally installed. However, the absolute necessity for preheating the carbons before throwing on the full current, requires that some method be devised of cutting the current down to 75 ampères. The use of the occulting switch and rheostat, seems to be the simplest method of accomplishing that result.

77. It is recommended that the occulting switch and rheostat be retained on all the present lights and that it be installed on all lights in the future, or that some other simple method of securing a current of approximately 75 ampères be provided.

ARC MEASURING AND FOCUSSING DEVICE

78. With the present searchlight, focussing is effected by having the fire commander or other controlling officer direct the operator at the light to move the lamp mechanism back and forth until the controlling officer considers a proper focus to have been secured. There is no absolute standard by which to tell when the crater is in the focus of the mirror. As the carbons burn away the crater departs from the focus by irregular amounts and there is no way whatever for the operator to know what has happened. There should be a device that would throw an image of the arc on a graduated scale under the eye of the operator, who would then know whether the lamp was in focus, and the controlling officer would be relieved of the necessity of being continually on the watch to adjust the focussing.

79. From the results of the experiments as to the effect of varying the arc length, it appears that there may be a variation of 25 per cent in the amount of light in the beam due to this cause alone, and that relatively small changes in arc length may cause a material variation in the light emitted. There should be a device that will throw the image of the arc on a graduated scale in a suitable size for the operator to readily read the length. The same device can be so made as to indicate when the crater is in the focus as well as to measure the arc length. Such a device was improvised for these tests and contributed largely to the steadiness and uniformity of searchlight operation.

80. It is recommended that a satisfactory service arc-measuring and focussing device be developed and applied to all lights.

SIDE SIGHT-GLASS

81. Owing to the necessity for the operator to keep the arc under observation during a large part of the time, the side sight-glass should be made about 3 inches by 4 inches, so that the operator can readily use both eyes to watch the arc. Facilities should be provided, by the use of platforms or otherwise, for the operator conveniently and comfortably to observe the arc.

INSTRUMENTS

82. The ammeters and voltmeter showing the arc current and voltage should be in view of the operator, without necessity for his changing his position, since experience shows that it is impracticable to secure good searchlight operation under any other conditions.

ROTATING DEVICE*

83. If carbons would burn evenly and the arc stream flow from the center of one carbon to the center of the other, we should then have the ideal carbon, as far as steadiness of burning and ease of handling are concerned. The crater would be symmetrical and remain in the focal axis. By means of the horizontal and vertical adjusting handles, and as a result of constant attention, the carbons can be controlled to a certain degree.

84. But when the carbons burn unevenly and form lips, the positive carbon must be shifted to take care of this unevenness, and this causes the crater to be shifted from the focal axis, which should be avoided as much as possible. One of the troubles with the carbons has been the tendency of the arc to shift and burn from the edge of the negative carbon. When this happens, it is necessary to move the positive to meet the arc in order to prevent the light from going out. Then the positive carbon burns one edge; and, unless the arc comes back to the center soon, the edge burns away and the arc jumps off and breaks. If the positive carbon could be rotated so that the arc could be held on the positive carbon and the carbon burned symmetrically until the arc returned to the center of the negative, most of the troubles of burning would be removed.

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* See article by Captain J. C. Ohnstad, C. A. C., *Rotating Device for Searchlight Carbons*, p. 242, Vol. 36, JOURNAL OF THE UNITED STATES ARTILLERY (Whole No. 112, November-December, 1913).

is unsatisfactory. With the installation of a shutter, this device becomes useless for the purpose for which originally installed. However, the absolute necessity for preheating the carbons before throwing on the full current, requires that some method be devised of cutting the current down to 75 ampères. The use of the occulting switch and rheostat, seems to be the simplest method of accomplishing that result.

77. It is recommended that the occulting switch and rheostat be retained on all the present lights and that it installed on all lights in the future, or that some other method of securing a current of approximately 75 provided.

ARC MEASURING AND FOCUSSING DEVICE

78. With the present searchlight, focussing is
having the fire commander or other controlling
the operator at the light to move the lamp
and forth until the controlling officer
to have been secured. There is no absolute
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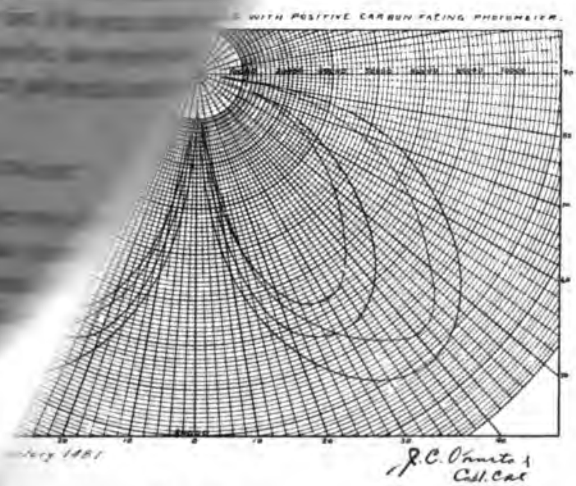


FIG. 26.

y for closer attention on the part of the operator
a tendency of the negative point to burn off bluntly
tapering back. The manufacturers state that this
had its origin in the baking and can be corrected in
orders. Fig. 26 shows the average apparent candle-
of the factory-made carbons.

88. Based on the results of the experimental work, speci-
tions for 60-inch carbons are recommended as shown on
ges 177 to 179.

89. In drawing up these specifications certain definite performances were called for, which were in each case based on the actual performances secured upon test with a reasonable allowance for such irregularity in product as might properly be expected. The details of methods of manufacture and the

85. The rotating device shown in Fig. 25, accomplishes this. By constant attention and with the aid of the horizontal, vertical, and rotating adjusting handles, carbons can be made to burn with very little trouble. In all the tests described herein the rotating device was used. It has been in use on the searchlight at the Coast Artillery School in the Department of Engineering and Mine Defense for nearly two years. Without exception, every operator who has used it, speaks of the advantages of its use. Over 200 carbons have been burned using this device.

FIG. 25. 1519

FIELD RHEOSTAT

86. The field rheostat of the generator should, when practicable, be carried to the switchboard at the searchlight.

REVISED SPECIFICATIONS FOR 60-INCH CARBONS

87. The factory-made carbon and the necessary personnel became available November 4th, 1913; so a series of runs were made in the laboratory and at the searchlight under the same

conditions as existed during the regular test, in order to determine whether the carbons manufactured on a commercial basis were equal to those developed in the laboratory. The results of the runs indicated that the factory-made carbons gave about 12 per cent less light, and that, while they fulfilled the specifications as to the number of outs, steadiness of burning, etc., they required more attention on the part of the operator to obtain satisfactory burning. The reduction in the amount of light was apparently due to the increased depth of the crater, the small diameter of the crater, and the bluntness of the negative, all resulting from the greater hardness of the outside of the shell as compared with the inner portions.

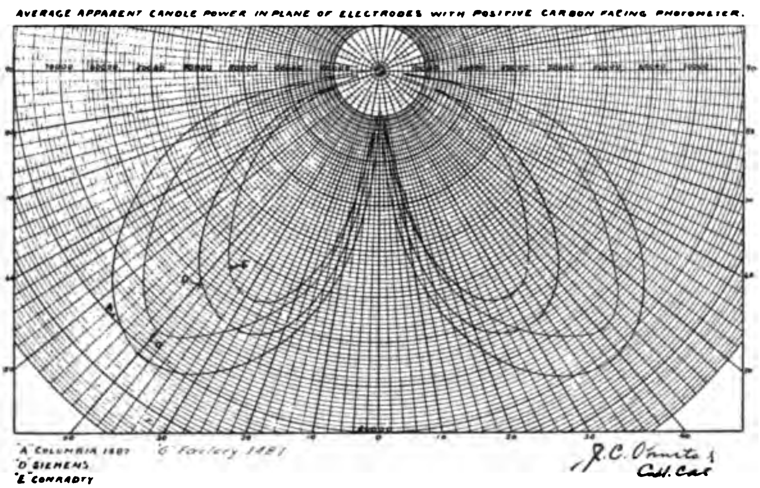


FIG. 26. 1520

The necessity for closer attention on the part of the operator came from a tendency of the negative point to burn off bluntly instead of tapering back. The manufacturers state that this difficulty had its origin in the baking and can be corrected in future orders. Fig. 26 shows the average apparent candle-power of the factory-made carbons.

88. Based on the results of the experimental work, specifications for 60-inch carbons are recommended as shown on pages 177 to 179.

89. In drawing up these specifications certain definite performances were called for, which were in each case based on the actual performances secured upon test with a reasonable allowance for such irregularity in product as might properly be expected. The details of methods of manufacture and the

composition of shell and core were left to the discretion of the manufacturer. Whenever sizes and dimensions were prescribed, they were such as the use of service apparatus required.

Searchlight Operation

90. Observance of the following suggestions, combined with a large amount of experience gained from actual work at the arc, should secure satisfactory searchlight operation:

a. The carbons should be inserted with the bases flush with the holders, with the axes in prolongation of each other, and with the clamps well tightened. Owing to the difference in the expansion of the carbons and the metal holders, the carbons become loose after they are heated and should be retightened after the arc has been burning for some time.

b. All carbons should be first heated with a current of 75 ampères for fifteen minutes with the points locked together; then they should be allowed to feed apart as far as possible with a current of 75 ampères, before throwing on the full current. Tests have shown that it is the gradual heating of the carbons, and not the dryness, that prevents cracking.

c. The operator should have the arc under observation continually from the time the arc is struck.

d. The normal current is 200 ampères at 65 volts for all 60-inch searchlights, regardless of previous rating, and should be carefully maintained. The amount of light varies directly with the wattage expended in the arc.

e. An arc length of three quarters of an inch gives the best light.

f. The formation of graphite globules on the point of the negative, results from too short an arc and careless operation. In case such globules form, satisfactory operatiou can be obtained only by the insertion of a new negative.

g. The fire commander should direct and be responsible for the focussing of the beam. The operator cannot tell when his light is in focus.

h. The positive and negative carbons should preferably be burned in pairs as supplied by the manufacturer.

i. Hissing occurs when the arc stream leaves the core. It may be due to careless operation, permitting the carbon to burn on one side, inaccurate alignment of the carbons, the bluntness of the negative point, too long an arc length, the core material separating from the shell, or the core cavity not being

entirely filled. The usual cause is inattention on the part of the operator. The sound of the hum of the arc will usually indicate whether the arc is burning quietly; a rise in the pitch gives warning of future troubles. The judicious use of the right-and-left, up-and-down, and rotating devices in securing good alignment, will cure the trouble. These same devices should be used to throw the arc stream back to the core when it wanders.

j. A minimum line voltage of 110 is required for the best results, and the resistance of the line rheostat should be made sufficiently large to regulate the arc voltage for a value of 65 volts at 200 ampères.

Special Carbons

ULTRA-VIOLET CARBONS

91. Experiments were undertaken with sources of light in which the shorter wave lengths predominated, with a view to the development of a core composition which would give a beam specially suited for use during hazy or foggy atmospheric conditions. The National Carbon Company made up a lot of carbons containing a core composition giving a high percentage of ultra-violet rays, aud a test was made one night when a slight fog existed. The beam showed a decrease in available light; and, after the fog had increased till no more photometric readings could be obtained, the carbons were replaced by a pair of No. 1487 carbons, after which small readings were obtained. Even in a fog, No. 1487 gave better results than the ultra-violet. During the burning of this ultra-violet carbon, the operators at the searchlight suffered from headaches and a very depressed feeling. These carbons are dangerous to handle and only one pair has been tried. Each of the various core compositions tried gave a distinctive color to the beam, so that a good opportunity was given to study the illuminating values of various shades. The degree of illumination given the target varied with the intensity of the light at the source, and this increased with the rise in temperature of volatilization of shell and core.

92. Solid carbon electrodes gave the most light but were very unsatisfactory in burning, so that the use of a core was essential. That core composition gave the best results which volatilized at the highest temperature, evloved the minimum of flame, made the crater of the positive carbon the sole source

of light, burned to such shape as to cause the zones of maximum candle-power to fall farthest from the axis of the mirror, and maintained the arc stream in the center of the carbon cores. The introduction of mineral components into the composition for the purpose of giving color to the beam, was always accompanied by a lowering of the temperature of volatilization, with a decrease of light and illumination and the production of a flame between the crater and the mirror which absorbed the light and frequently gave a deposit on the mirror and mechanism.

SPECIAL SHELLS

93. Further experiments were carried on after the first type of carbon had been adopted looking to a further improvement in the steadiness of burning, and the National Carbon Company made up several pairs having a new shell composition. Upon being given a "life" test in the standard searchlight, the carbons burned much more steadily than the approved type, the arc not going out once in the five-hour run. The arc required less care and burned quietly and uniformly. A pair of the carbons was then given a photometric test in the laboratory, and they gave approximately the same candlepower as the approved type.

94. The performance showed such an improvement as to warrant further development. The carbons are softer, finer grained, and more uniform in structure; but they are also more brittle, so the percentage of loss in moulding and baking is considerably higher and the cost will be increased appreciably.

95. It is recommended that the experimental work on this lot of carbons be continued until a carbon of suitable qualities can be produced on a commercial basis.

36-INCH, 30-INCH, AND 24-INCH CARBONS

96. Instructions having been received to prepare specifications for 36-inch, 30-inch, and 24-inch carbons, it was decided to utilize the same type of core composition as was found satisfactory in the 60-inch carbons, and orders were placed for the manufacture of several pairs of each size. Upon receipt of the carbons some two months later, a series of tests in the service light and in the laboratory were carried out. From the results of the tests the specifications on page 179 to 184 are recommended for 36-inch, 30-inch, and 24-inch lights.

Specifications for Carbons

60-inch searchlight

(1) *Size and shape.*—The positive carbons shall be 2 inches in diameter and 15 inches long, and the negative carbons shall be $1\frac{3}{8}$ inches in diameter and 12 inches long, with an

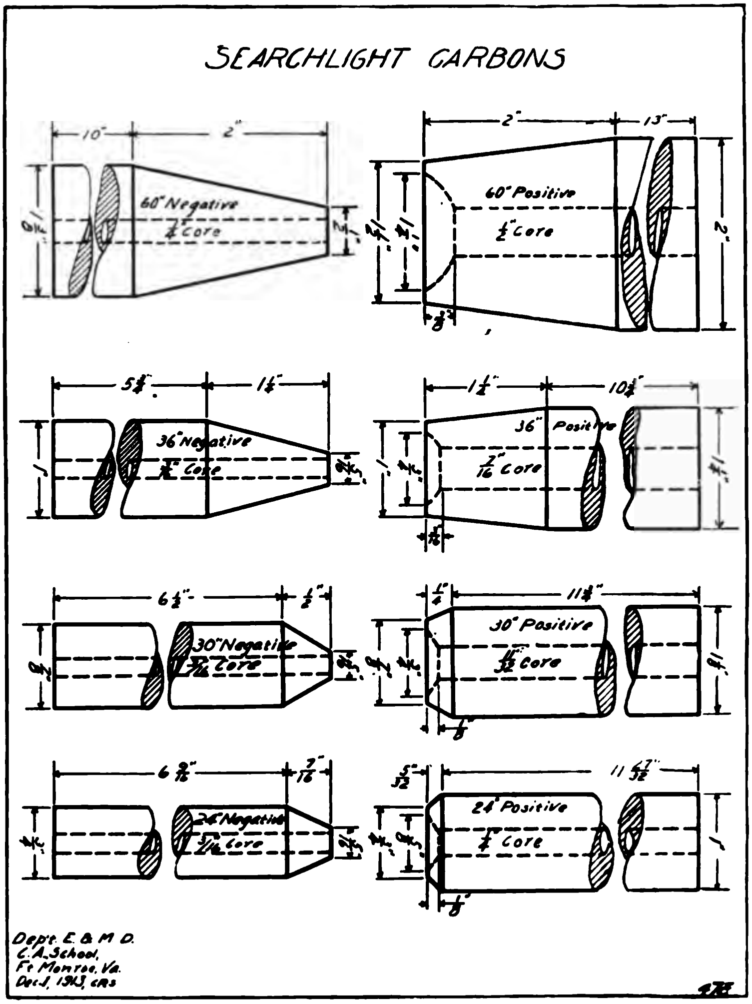


Fig. 27. 1521

allowable variation of 0.05 inch in the diameter and of ¼ inch in the length of both carbons. All carbons shall be cylindrical, with an allowable flatness of .025 inch. The detailed dimensions of the carbons shall be as shown in Fig. 27.

(2) *Straightness.*—Carbons shall be carefully sorted by the manufacturer for straightness by being rolled down a trued steel plate. Any carbon found to rise off the plate $\frac{1}{16}$ inch or more at the pointed end, when the holder end is placed on the plate, shall be rejected as unsatisfactory.

(3) *Physical qualities.*—All carbons shall be of sufficiently homogeneous and well-knit structure to undergo shipping and ordinary handling without breakage. Carbons shall be of a uniform texture, free from cracks and other flaws, and of first-class mechanical appearance. The cores shall not separate from the shell during shipment or burning, shall completely fill the core cavity, and shall not burn more than $\frac{1}{4}$ inch back of the adjacent surface of the crater. The composition of the core material shall be determined by the manufacturer to secure the maximum light and steadiness of burning.

(4) *Burning qualities.*—Carbons shall not give off noxious or injurious gases, nor cause a deposit on the mirror, nor give a light which produces injurious effects on operators or observers. The carbons shall burn in the service lamp mechanism steadily, quietly, and with maximum brilliancy, without requiring an undue amount of attention on the part of the operator. The negative carbon shall maintain its original tapering point during burning.

(5) *Voltage and current.*—The normal voltage across the arc shall be 65 volts, with an allowable variation of ± 5 volts. The normal current at 65 volts shall be 200 ampères.

(6) *Test of burning qualities.*—The quality of burning shall be determined from the average performance of about 1 per cent of each lot of carbons, to be selected by the inspector at random. All test carbons shall be heated for 15 minutes before being tested.

One half the test carbons shall be burned to determine the mean spherical candle-power through the aperture of 120° usually occupied by the mirror. The mean spherical candle-power through the above aperture of 120°, determined after the arc has been burning for an hour and a half, shall not be less than 60,000.

The other half of the test carbons shall be burned during life for the purpose of determining the average brilliancy of illumination, number of outs, rate of burning, life, chipping, cracking, ease of handling, and steadiness of burning.

The average brilliancy of the beam shall not be less than 2 foot-candles at 2000 yards, or its equivalent.

The number of times the arc goes out shall not exceed an average of three times per carbon during six hours, and for any one carbon shall not exceed six times.

The positive carbon shall not burn faster than 1.2 inches per hour at 65 volts and 200 ampères. The usual life of a pair of carbons shall not be less than six hours.

Carbons shall not, during burning, flake injuriously nor develop cracks which cause pieces to fall out exceeding ½ inch in greatest dimension. If one of five test carbons chips to this extent, another test shall be made on five additional carbons, and, if the same defect occurs, it shall be cause for the rejection of the lot.

No carbon shall burn with less than 80 per cent of the average intensity of the test carbons for more than 10 per cent of the time, including outs due to defective carbons.

All carbons shall burn steadily, without hissing or excessive flame, during at least 90 per cent of the "life" test.

(7) *Marking.*—Each carbon shall bear marks indicating the maker, type, lot, and year of manufacture.

(8) *Packing.*—Carbons shall be securely packed in dry sawdust in air-tight tin cans, each can being marked with the number of carbons, and the size, type, and year of manufacture of the carbons. The carbons shall be packed in pairs, ten pairs to the can.

36-INCH SEARCHLIGHT

(1) *Size and shape.*—The positive carbons shall be 1¼ inches in diameter and 12 inches long, and the negative carbons shall be 1 inch in diameter and 7 inches long, with an allowable variation of 0.05 inch in the diameter and of ¼ inch in the length of both carbons. All carbons shall be cylindrical, with an allowable flatness of .025 inch. The detailed dimensions of the carbons shall be as shown in Fig. 27.

(2) *Straightness.*—Carbons shall be carefully sorted by the manufacturer for straightness by being rolled down a trued steel plate. Any carbon found to rise off the plate $\frac{1}{16}$ inch or more at the pointed end, when the holder end is placed on the plate, shall be rejected as unsatisfactory.

(3) *Physical qualities.*—All carbons shall be of sufficiently homogeneous and well-knit structure to undergo shipping and ordinary handling without breakage. Carbons shall be of a uniform texture, free from cracks or other flaws, and of first-class mechanical appearance. The cores shall not sep-

arate from the shell during shipment or burning, shall completely fill the core cavity, and shall not burn more than ¼ inch back of the adjacent surface of the crater. The composition of the core material shall be determined by the manufacturer to secure the maximum light and steadiness of burning.

(4) *Burning qualities.*—Carbons shall not give off noxious or injurious gases, nor cause a deposit on the mirror, nor give a light which produces injurious effects on operators or observers. The carbons shall burn in the service lamp mechanism steadily, quietly, and with maximum brilliancy, without requiring an undue amount of attention on the part of the operator. The negative carbon shall maintain its original tapering point during burning.

(5) *Voltage and current.*—The normal voltage across the arc shall be 60 volts, with an allowable variation of ± 5 volts. The normal current at 60 volts shall be 130 ampères.

(6) *Test of burning qualities.*—The quality of burning shall be determined from the average performance of about 1 per cent of each lot of carbons, to be selected by the inspector at random. All test carbons shall be heated for 10 minutes before being tested.

One half the test carbons shall be burned to determine the mean spherical candle-power through the aperture of 120° usually occupied by the mirror. The mean spherical candle-power through the above aperture of 120°, determined after the arc has been burning for an hour and a half, shall not be less than 35,000.

The other half of the test carbons shall be burned during life for the purpose of determining the average brilliancy of illumination, number of outs, rate of burning, life, chipping, cracking, ease of handling, and steadiness of burning.

The average brilliancy of the beam shall not be less than 1.7 foot-candles at 2000 yards, or its equivalent.

The number of times the arc goes out shall not exceed an average of three times per carbon during six hours, and for any one carbon shall not exceed six times.

The positive carbons shall not burn faster than 1.0 inch per hour at 60 volts and 130 ampères. The useful life of a pair of carbons shall not be less than five hours.

Carbons shall not, during burning, flake injuriously nor develop cracks which cause pieces to fall out exceeding ½ inch in greatest dimension. If one of five test carbons chips to this extent, another test shall be made on five additional car-

bons, and, if the same defect occurs, it shall be cause for the rejection of the lot.

No carbon shall burn with less than 80 per cent of the average intensity of the test carbons for more than 10 per cent of the time, including outs due to defective carbons.

All carbons shall burn steadily, without hissing or excessive flame, during at least 90 per cent of the "life" test.

(7) *Marking.*—Each carbon shall bear marks indicating the maker, type, lot, and year of manufacture.

(8) *Packing.*—Carbons shall be securely packed in dry sawdust in air-tight tin cans, each can being marked with the number of carbons, and the size, type, and year of manufacture of the carbons. The carbons shall be packed in pairs, ten pairs to the can.

30-INCH SEARCHLIGHT

(1) *Size and shape.*—The positive carbons shall be $1\frac{1}{8}$ inches in diameter and 12 inches long, and the negative carbons shall be $\frac{7}{8}$ inch in diameter and 7 inches long, with an allowable variation of 0.05 inch in the diameter and of $\frac{1}{4}$ inch in the length of both carbons. All carbons shall be cylindrical, with an allowable flatness of .025 inch. The detailed dimensions of the carbons shall be as shown in Fig. 27.

(2) *Straightness.*—Carbons shall be carefully sorted by the manufacturer for straightness by being rolled down a trued steel plate. Any carbon found to rise off the plate $\frac{1}{16}$ inch or more at the pointed end, when the holder end is placed on the plate, shall be rejected as unsatisfactory.

(3) *Physical qualities.*—All carbons shall be of sufficiently homogeneous and well-knit structure to undergo shipping and ordinary handling without breakage. Carbons shall be of a uniform texture, free from cracks or other flaws, and of first-class mechanical appearance. The cores shall not separate from the shell during shipment or burning, shall completely fill the core cavity, and shall not burn more than $\frac{1}{4}$ inch back of the adjacent surface of the crater. The composition of the core material shall be determined by the manufacturer to secure the maximum light and steadiness of burning.

(4) *Burning qualities.*—Carbons shall not give off noxious or injurious gases, nor cause a deposit on the mirror, nor give a light which produces injurious effects on operators or observers. The carbons shall burn in the service lamp mechanism steadily, quietly, and with maximum brilliancy, without

requiring an undue amount of attention on the part of the operator. The negative carbon shall burn to a tapering point.

(5) *Voltage and current.*—The normal voltage across the arc shall be 50 volts, with an allowable variation of ±5 volts. The normal current at 50 volts shall be 80 ampères.

(6) *Test of burning qualities.*—The quality of burning shall be determined from the average performance of about 1 per cent of each lot of carbons, to be selected by the inspector at random. All test carbons shall be heated for 10 minutes before being tested.

One half the test carbons shall be burned to determine the mean spherical candle-power through the aperture of 120° usually occupied by the mirror. The mean spherical candle-power through the above aperture of 120°, determined after the arc has been burning for an hour and a half, shall not be less than 20,000.

The other half of the test carbons shall be burned during life for the purpose of determining the number of outs, rate of burning, life, chipping, cracking, ease of handling, and steadiness of burning.

The number of times the arc goes out shall not exceed an average of two times per carbon during four hours, and for any one carbon shall not exceed four times.

The positive carbon shall not burn faster than 1.0 inch per hour at 50 volts and 80 ampères. The useful life of a pair of carbons shall not be less than five hours.

Carbons shall not, during burning, flake injuriously nor develop cracks which cause pieces to fall out exceeding ½ inch in greatest dimension. If one of five test carbons chips to this extent, another test shall be made on five additional carbons, and, if the same defect occurs, it shall be cause for the rejection of the lot.

No carbon shall burn with less than 80 per cent of the average intensity of the test carbons for more than 10 per cent of the time, including outs due to defective carbons.

All carbons shall burn steadily, without hissing or excessive flame, during at least 90 per cent of the "life" test.

(7) *Marking.*—Each carbon shall bear marks indicating the maker, type, lot, and year of manufacture.

(8) *Packing.*—Carbons shall be securely packed in dry sawdust in air-tight tin cans, each can being marked with the number of carbons, and the size, type, and year of manufacture

of the carbons. The carbons shall be packed in pairs, twenty-five pairs to the can.

24-INCH SEARCHLIGHT

(1) *Size and shape.*—The positive carbons shall be 1 inch in diameter and 12 inches long, and the negative carbons shall be ¾ inches in diameter and 7 inches long, with an allowable variation of 0.05 inch in the diameter and of ¼ inch in the length of both carbons. All carbons shall be cylindrical, with an allowable flatness of .025 inch. The detailed dimensions of the carbons shall be as shown in Fig. 27.

(2) *Straightness.*—Carbons shall be carefully sorted by the manufacturer for straightness by being rolled down a trued steel plate. Any carbon found to rise off the plate $\frac{1}{16}$ inch or more at the pointed end, when the holder end is placed on the plate, shall be rejected as unsatisfactory.

(3) *Physical qualities.*—All carbons shall be of sufficiently homogeneous and well-knit structure to undergo shipping and ordinary handling without breakage. Carbons shall be of a uniform texture, free from cracks or other flaws, and of first-class mechanical appearance. The cores shall not separate from the shell during shipment or burning, shall completely fill the core cavity, and shall not burn more than ¼ inch back of the adjacent surface of the crater. The composition of the core material shall be determined by the manufacturer to secure the maximum light and steadiness of burning.

(4) *Burning qualities.*—Carbons shall not give off noxious or injurious gases, nor cause a deposit on the mirror, nor give a light which produces injurious effects on operators or observers. The carbons shall burn in the service lamp mechanism steadily, quietly, and with maximum brilliancy, without requiring an undue amount of attention on the part of the operator. The negative carbon shall burn to a tapering point.

(5) *Voltage and current.*—The normal voltage across the arc shall be 48 volts, with an allowable variation of ± 5 volts. The normal current at 48 volts shall be 50 ampères.

(6) *Test of burning qualities.*—The quality of burning shall be determined from the average performance of about 1 per cent of each lot of carbons, to be selected by the inspector at random. All test carbons shall be heated for 10 minutes before being tested.

One half the test carbons shall be burned to determine the mean spherical candle-power through the aperture of 120°

usually occupied by the mirror. The mean spherical candlepower through the above aperture of 120°, determined after the arc has been burning for an hour and a half, shall not be less than 10,000.

The other half of the test carbons shall be burned during life for the purpose of determining the number of outs, rate of burning, life, chipping, cracking, ease of handling, and steadiness of burning.

The number of times the arc goes out shall not exceed an average of two times per carbon during four hours, and for any one carbon shall not exceed four times.

The positive carbon shall not burn faster than 1.0 inch per hour at 48 volts and 50 ampères. The useful life of a pair of carbons shall not be less than five hours.

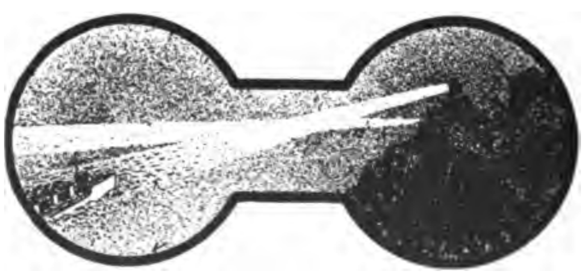
Carbons shall not, during burning, flake injuriously nor develop cracks which cause pieces to fall out exceeding ½ inch in greatest dimension. If one of five test carbons chips to this extent, another test shall be made on five additional carbons, and, if the same defect occurs, it shall be cause for the rejection of the lot.

No carbon shall burn with less than 80 per cent of the average intensity of the test carbons for more than 10 per cent of the time, including outs due to defective carbons.

All carbons shall burn steadily, without hissing or excessive flame, during at least 90 per cent of the "life" test.

(7) *Marking.*—Each carbon shall bear marks indicating the maker, type, lot, and year of manufacture.

(8) *Packing.*—Carbons shall be securely packed in dry sawdust in air-tight tin cans, each can being marked with the number of carbons, and the size, type, and year of manufacture of the carbons. The carbons shall be packed in pairs, twenty-five pairs to the can.



COAST DEFENSE IN THE CIVIL WAR*

FORT SUMTER, CHARLESTON, S. C.

(Subsequent Attacks)

By 1st Lieut. WALTER J. BUTTGENBACH, Coast Artillery Corps

General Situation

As one after another the ports of the Confederacy were regained to Federal control, Charleston harbor became again the center of interest. Expedition after expedition was gotten ready, necessitating many subsidiary operations, and all in an effort to acquire Fort Sumter. For, on account of the difficulty of maintaining an effective blockade of it, Charleston harbor remained a point of entrance for blockade runners; and there was also sentiment associated with the desire for its recapture, Charleston being considered by many to have been the cradle of the Confederacy, in fact, the place of birth of the very idea of secession. Then Fort Sumter's wresting from Federal control in April, 1861, may literally be said to have brought on the conflict between the two contending portions of the Union. So it was felt by many in the North, that the war should be brought home to the city that had first defied Federal power.

From the military standpoint, except being a harbor for blockade runners, Charleston was relatively unimportant, and of not near the value of some of the other harbors on the southern coast, as, for example, New Orleans.

Special Situation

During the time determined attacks on the coast were being made elsewhere, there was a blockading fleet off Charleston harbor; though from time to time during the war expeditions were sent there also, some being total failures and others partial successes. Political conditions oftentimes conflicted with military ones, and the expeditions against Charleston

*See note to "Coast Defense in the Civil War, Fort Sumter, Charleston, S. C. (First Attack)," in Journal U. S. Artillery, for March-April, 1912.

were subordinate, which will partially explain the long drawn out contest. The time came, however, when it was felt that it was necessary to close up this harbor as being one of the few places still open to blockade runners, and, ultimately, practically the last open harbor of the South.*

The only method to break up the traffic was the actual possession of the waters of Charleston harbor, and not a blockade of its entrance.

In this paper an attempt will be made to sketch in the history of the defense of Charleston, commencing with the withdrawal of Federal power from Fort Sumter and ending with the abandonment of Charleston by the Confederates—a chronicle of some four years and a fitting end to this series of papers.

Opposing Forces

CONFEDERATE

The original works have been enumerated in the first paper of this series, "Fort Sumter, Charleston, S. C. (First Attack)," and, after the Federal withdrawal, we find the Confederates busily engaged repairing the damage done in that first attack.

It was contemplated to restore and complete Fort Sumter according to its original plan. The embrasures in the upper casemates were filled in with fresh masonry, leaving only narrow loopholes, excepting three at the main salient, where the embrasures were completed and armed. A large traverse was built at the eastern angle of the ramparts, so as to protect the barbette guns of the right face from enfilade fire by the ships. The magazines at the eastern and western extremities of the gorge were strengthened by an exterior work of stone masonry, reinforcing the gorge wall at each locality to a height of some fifteen feet. Near the eastern side of the sally-port a caponnière was built of brick, mounting two casemate howitzers for the defense of the quay and pier. Traversing circles were arranged so guns could be traversed continuously and be kept laid on moving targets. The hot-shot furnaces were restored, and barracks rebuilt, though with walls not as high as they were formerly. Also a bakery, a shoe factory, and a

*Blockade runners came in and out of Charleston harbor to the last. "Actually twenty-one vessels ran in after the ruin of Sumter until the evacuation of Charleston."—Ammen, *The Atlantic Coast*, page 141 (Scribner Series, *The Navy in the Civil War*).

distilling plant were arranged for, as well as cisterns for the storage of rain water.

Additional batteries also were built. Battery Bee, one half mile west of Fort Moultrie and on the same island, was built in 1862; then there was Battery Beauregard, about the same distance to the east, and Battery Marshall at the eastern end of the island. These works were of great strength, made of sand, well sodded, and furnished with magazines and bombproof quarters.

Fort Ripley was built the same year, on "Middle Ground," a shoal between Castle Pinckney and Fort Johnson and two miles inside of Fort Sumter. Its plan was square, and it was scarcely shot-proof, consisting of a ballasted cribwork of heavy timber.

Against a hostile approach from Stono River, were laid out in the interior of James Island extensive, but not very strong, lines for field artillery and infantry, their right resting on Stono River near Wappoo Cut at Fort Pemberton, a large, well built work, heavily armed, and their left resting on the marshes of Folly River at Secessionville, where Fort Lamar was located. This work was of lighter construction than Fort Pemberton. The outposts of James Island in this direction were at Cole's Island and Battery Island, connected by causeways to the southern extremity of the island and strengthened by guns bearing on Stono Inlet and Stono River. However, in the spring of 1862 these islands were given up as points of defense, they serving thereafter only as picket stations.

The works on Morris Island which had been built to engage Fort Sumter in April, 1861, gave place to two works of considerable importance, Battery Gregg, located at Cumming's Point, and Battery (or Fort) Wagner about a mile further south. The former was a work with thick parapets, magazine, and bombproof, designed to mount three guns, whose field of fire would include both the channel and the island.

Battery Wagner, as it is called in Confederate reports, or Fort Wagner, in Federal reports, was situated at the narrowest part of the island and extended all the way across. It was orginally built in 1862; and in 1863 it was further strengthened by the addition of a heavy flanking battery bearing on the channel, and by a parapet suitable for infantry fire closing the gorge. Its sea face was about 300 feet along

the beach, and its total of land faces nearly 800 feet across the island.

Batteries were also contemplated to be built at the southern end of Morris Island, but none were completed at the time of the attack by the ironclad squadron in April, 1863.

In 1862 a double line of pine timber piles was driven across the Middle Ground shoal, on a line due north of Fort Johnson and some 600 or 700 yards in front of Fort Ripley. The piles extended in a line over a mile and a quarter long, leaving a space of three quarters of a mile of deep water off Fort Johnson. Obstructions were also put in the Stono River, off Battery Island and off Fort Pemberton. A boom of heavy timber, weighted and coupled with iron, was also built and anchored across the channel between Forts Moultrie and Sumter. The gales and currents, however, were too strong; so this boom, being twice broken, was finally abandoned, although some of its remaining sections were later combined in a sort of rope obstruction, which was continuous at first and consisted of three cables, the bottom one being anchored and the upper one arranged to float. This, too, being soon broken, sections of it were arranged with barrel floats attached to a net-work of torpedoes; and this obstruction later proved itself of value against the attack of Federal vessels.*

About March, 1863, fixed torpedoes, or mines, were placed in the harbor. Two boilers about three feet diameter and eighteen feet long, filled with 3000 lbs. of powder, were planted in the harbor and electrically connected to shore; these, however, gave no results.†

Several war vessels were built about the end of 1862 on the general plans of the *Merrimac*. The *Palmetto State* had 4-inch plating, a battery of one 80-pdr. forward, one 60-pdr. aft, and one 8-inch shell gun on each broadside. The *Chicora* had six guns, two 9-inch smooth bores and four 60-pdr. rifles. These vessels, however, were not much of a factor in the

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*In no case during operations did the Federal vessels ever advance up to, or attempt to cut through, the obstructions above Fort Sumter, which were said to have been more dreaded by the ships than the batteries; and it is stated that their constantly recurring derangement and inefficiency continued for nearly two years undiscovered by the Federal Navy. (See Chap. VIII, Johnson's *The Defense of Charleston Harbor.*)

† As a matter of interest, it may be stated that the *New Ironsides* was over one of these mines for several hours during the attack of April 7, 1863, and attempts were made to set the mine off, but without avail. It was thought that the wires in some way became cut, or that a teamster ran over them with a loaded wagon.

defense; nor were the other minor vessels built later; so none need be considered.

On September 15, 1862, General Beauregard took command of the defenses of Charleston Harbor, and it may be of interest to consider in a general way the armament of the various works then constituting his command.*

1. Fort Sumter, 79 guns of various calibers from 32-pdrs. to 8-inch columbiads, and seven 10-inch mortars. The fort was garrisoned by some 400 men of the 1st South Carolina Artillery.

2. Fort Moultrie, 38 guns, from 24-pdrs. to 8-inch columbiads. The garrison consisted of 300 men of the 1st South Carolina Infantry.

3. Battery Beauregard, on Sullivan's Island and in advance of Fort Moultrie so as to protect the approach from the east, had five guns.

There were in addition four sand batteries at the west end of the island protecting a boom, then in process of construction across the Fort Sumter Channel. These batteries had at that time only four guns, two being 10-inch columbiads, and the batteries themselves were not finished.

4. The "Neck" battery on Morris Island, later called Battery Wagner, also referred to as Fort Wagner, was an open work intended to defend the approach to Fort Sumter. It was intended for eleven guns and later became a formidable work, so will be mentioned again.

5. A small work, Fort Ripley, equidistant from Castle Pinckney and Fort Johnson, had two guns.

6. Castle Pinckney, armed with nine 24-pdrs. and one rifled 24-pdr. was a work of but little value.

7. Fort Johnson, near the northeast end of James Island with one 32-pdr., was likewise a work of little significance.

The Confederate troops in South Carolina at this time were 6564 infantry, 1787 artillery on duty with guns of position, 1379 field artillery, and 2817 cavalry, a total of 12,547.

About six months later, we find the armament stated to be as follows:†

James Island

Fort Johnson (5 guns and 1 mortar)	6 guns

* See *Battles and Leaders of the Civil War*, Vol. IV, page 2.

† See Johnson's *The Defense of Charleston Harbor.*

Battery Glover, opposite White Point Garden in the city	5	guns
Battery Means, near the Ashley mouth of Wappoo creek	2	"
Fort Pemberton near the Stono mouth Wappoo Creek	15	"
Western division of lines (2600 yards)	17	"
Eastern division of lines (2600 yards)	20	"
Battery Reed, on right flank Fort Lamar	2	"
Secessionville (Fort Lamar) (13 guns and 1 mortar)	14	"

In all, 81 guns, of which, however, only 13 were on the harbor.

Morris Island

Battery Wagner	7	guns
Battery Gregg	2	"
Total	9	"

Sullivan's Island

Battery Marshall, Breach Inlet	8	guns
Battery Beauregard	6	"
Fort Moultrie	24	"
Battery Bee	10	"
Total	48	"

Fort Sumter

In casemates	40	guns
In barbette, on ramparts	45	"

85 guns and 7 mortars.

Of the guns and mortars at Fort Sumter, however, only those on the eastern, or right, face were brought into action, namely 37 guns and seven 10-inch seacoast mortars; and since among those were 13 smooth-bore 32-pdrs., of little value against armored vessels, and since the fire of the mortars was very uncertain, the actual effective armament could probably be said to have been no more than 24 guns, as follows:

4 10-inch columbiads,
2 9-inch Dahlgren,
2 7-inch Brooks rifles,

8 8-inch columbiads and navy shell guns,
7 42-pdrs., rifled and banded,
1 32-pdr., rifled and banded.

The garrison consisted of seven companies of the 1st Regiment, South Carolina Artillery, total of about 550 men and officers.

The works on Sullivan's and Morris Islands, in connection with the east half of Fort Sumter, formed the first defense line and comprised some 69 guns, from which a converging fire could be poured into an attacking fleet coming up the main channel. Although these guns were of various calibers and various types, they were manned by a dependable garrison, the men and officers being mostly from Charleston and their exact knowledge of approaches, ranges, and local conditions giving them a tremendous advantage.

Somewhat nearer to the city, about 2200 yards inside Cumming's Point, was an old earth work, Fort Johnson, which afterwards was rebuilt and armed with five heavy guns, including one 10-inch mortar. This work was of great value, especially later, as its character changed and the Federal lines came closer to the city. Between this and Castle Pinckney, some 1800 yards from the latter, was Fort Ripley, whose armament has already been mentioned.

Castle Pinckney, Fort Johnson, Batteries Bee and Ripley, and the west half of Fort Sumter formed the second defense line.

There were also guns just off Charleston itself, and detached works about the city, making a third line; while between the second and third lines were other works, such as Glover, which were strengthened and added to as time went on.

It should be stated, however, that the armament as well as the number of troops available, changed from month to month, new batteries being built and old ones abandoned. In the case of Fort Sumter, the original character of an artillery post was wholly lost; the guns were transferred or destroyed and the fort became an infantry post. The details of armament will be mentioned from time to time when necessary; suffice it now, in order to bring out in a striking way the many changes that took place during the course of the operations, to present below the table taken from the map opposite page 91 of *The Atlantic Coast* (Ammen), showing the armament on February 18, 1865.

ARMAMENT OF REBEL FORTS

February 18th, 1865

Forts and Batteries	Dahlgren XI-in.	Columbiads, smooth 8 to 11-in.	Columbiads, rifled 8 and 10-in.	Brooks rifles 7, 8, 9, 10-in.	Blackeley's rifles 13-in.	Other rifles 5 to 10-in.	Smooth 5 to 10-in.	10-in. Mortars	Field pieces
Sullivan's Island	1	19	2	6		11	19	5	18
Sumter		2		2		1			5
James Island		9	3	5		1	2	5	8
Mt. Pleasant				2					
Castle Pinckney		3		1					
City Batteries	1	7		3	2				
City Intrenchment									6
	2	40	5	19	2	13	21	10	37

FEDERAL

Of the Federal forces, both military and naval, brought against the works, mention will be made in the narrative from time to time. Since numerous expeditions were made ready and their strength, organization, etc., varied with the task alloted them, no general résumé will be attempted.

Narrative of Events

ESTABLISHMENT OF BLOCKADE

After the evacuation of Fort Sumter, April 14, 1861, by Major Anderson, the Confederates had possession of all the harbor defenses at Charleston; and, while it was at first expected that a Federal attack would soon be made, as time wore on, Charleston became permeated with a feeling of security and of complete trust in the harbor defenses.

The blockade of Charleston may be said to have begun on May 10th, 1861, with the arrival of Captain McKean on the U. S. S. *Niagara*. But since the blockading vessels lay off the bar and a considerable distance out, blockade running was common, becoming in fact, a lucrative business, vessels being specially built to navigate the various channels, and in that way overcome the obstacle presented by the watching of the main channel.

In December, 1861, a collection of hulks and smaller vessels filled with stone were sunk by Captain Davis of the Federal Navy to close up the main channel; but this was not

much of a success, the old hulks being swept away or buried in the sand, so it became necessary to send additional vessels for blockade duty. Despite all efforts, however, blockade running did not come to an end till the occupation of Charleston by Federal troops.

JAMES ISLAND, 1862

In the summer of 1862 an attempt was made to reach Charleston by way of James Island, Federal troops under General Benham landing on James Island and making an assault on Fort Lamar which failed. Federal troops were on the island from June 16th to July 10th, when the Island was abandoned. The Federal losses were some 600 killed, wounded, and missing; and the Confederate losses, 204. The action had no result, so far as Charleston was concerned.

NAVAL ATTACK OF APRIL 7, 1863

Towards the close of 1862 the Navy Department began to assemble vessels before Charleston with the view of making a naval attack with monitors, hoping, because of the success at Port Royal, that the monitor fleet could silence the forts by gun fire. The army was asked to assist.

While these preparations were under way, the Confederate ironclads, *Palmetto State* and *Chicora*, on January 31, 1863, came down from the upper harbor and attacked the blockading squadron; and two vessels of the fleet, being shot through their steam drums, struck their colors, but the remainder of the fleet came to their assistance and drove the Confederate vessels back into the harbor. This action had but little effect on matters, except, perhaps, to make the naval Federal commander realize that a further growth of Confederate sea power was not desirable.

Finally, naval preparations being complete, on April 7th, 1863, Admiral Dupont made his attack with a squadron of ironclads against the forts, the attack being especially directed against Fort Sumter.

The attacking vessels consisted of the following:—*Weehawken, Catskill, Montauk, Nantucket, Passaic, Nahant,* and *Patapsco*, monitors, each mounting two guns; the *Keokuk*, with two fixed turrets having one gun in each turret; and the *New Ironsides*, a broadside armored ship mounting sixteen guns. Thus the attacking fleet had a total of 32 guns, of which twenty-

two were 11-inch smooth bores, seven 15-inch smooth bores, and three 8-inch Parrott rifles.

Fort Sumter at this particular time had some 80 guns and a garrison of 550 men. Fort Moultrie, with other batteries, took part, though at long range; for the attack, as has been said, was directed principally against Fort Sumter.

The fleet arrived off Charleston bar on the forenoon of the 5th, accompanied by transports, and the armored vessels crossed the bar on the 6th, it being intended to advance that day; but the weather being hazy, the advance was postponed and the squadron anchored about four miles and a half southeast of Fort Sumter.

Tuesday, April 7th, the day being clear, everything was made ready and the attack was expected by the forts. Federal troops under General Hunter were in Stono Inlet and on Folly Island. The Federal force aggregated about 13,000 men. The Confederate land forces of the 1st District, including all troops about the harbor, were about 11,000.

Admiral Dupont's plan was to pass the batteries on Morris Island without engaging them, to move directly upon Fort Sumter, and to attack Morris Island after the reduction of Sumter. The order of battle was line-ahead, or vessels advancing in single file, in the following order:—

Weehawken *Passaic* *Montauk* *Patapsco*	1st Division.
New Ironsides	Flagship.
Catskill *Nantucket* *Nahant* *Keokuk*	2nd Division.

The advance began about 1:45 P. M., the vessels moving slowly ahead against an ebb tide. The squadron passed Battery Wagner without either side's firing, the first shot not being fired till the leading monitor was about abreast of Fort Sumter, when it was fired from Fort Moultrie; the range, however, was too great. One gun on the *Passaic* fired in reply. It was now 2:50 P. M.

About this time the *Weehawken*, some 1100 yards from Fort Sumter, opened fire; and the barbette guns of the eastern flank of the fort commenced firing by battery at 3:00 P. M.,

the *Weehawken* having then reached a well-known buoy the range of which from the forts was accurately known. Thereupon all the guns that could be brought to bear from Fort Moultrie and Batteries Bee and Beauregard on Sullivan's Island, together with those from Battery Gregg on Cumming's Point, joined in with Fort Sumter.

The squadron came on, and by about 4:10 P. M. all its guns were in action; and there being about 100 guns altogether, counting those ashore as well as those afloat, now firing, the monitors at times were completely hidden in smoke. It was soon realized, however, that the vessels could not force their way past the forts, because not only of the heavy fire under which they were, but because also of the nature of the obstructions ahead. When the bombardment had been continued about two hours, Admiral Dupont decided to withdraw, intending, however, to renew the attack the next day; so sometime between 4:00 and 5:00 P. M. the order to withdraw from action was given, the fire of the squadron slackening and finally ceasing, though the forts continued to fire till the vessels had passed beyond extreme range. After the withdrawal of the fleet, a consultation of ships' captains was held.

Admiral Dupont, after getting detailed reports from his vessels, changed his plans and the attack was not renewed, the admiral stating in his report that "it would have converted the failure into a disaster." And though in his decision the admiral had the support of all his captains, yet after correspondence between him and the Secretary of the Navy, he was relieved on June 3rd, due in part to his unwillingness to renew the attack, and in part to his hostility to the use of monitors.

The vessels engaged anchored off the end of Morris Island for some five days till April 12th, when, with the exception of the *Keokuk*, which had sunk the day after the fight, they crossed the bar and dispersed, the monitors returning to Port Royal for repair, and the *New Ironsides* remaining with the blockading vessels outside the bar.

On the occasion of the naval attack of April 7th, 1863, the following land armament was in action:—

Fort Sumter (7 companies of artillery)

2 7-inch Brooks rifles,
2 9-inch Dahlgrens,
4 10-inch columbiads,

4 8-inch navy guns,
4 8-inch columbiads,
6 banded and rifled 42-pdrs.,
8 32-pdrs.,S. B.,
3 10-inch seacoast mortars,

—

Total 33 guns and mortars.

Fort Moultrie (5 companies of infantry)
9 8-inch columbiads,
5 32-pdrs., rifled and banded,
5 32-pdrs., S. B.,
2 10-inch mortars,

—

Total 21 guns and mortars.

Battery Bee on Sullivan's Island (3 companies of infantry)
5 10-inch columbiads,
1 8-inch columbiad,

—

Total 6 guns.

Battery Beauregard (2 companies)
1 8-inch columbiad,
2 32-pdrs., rifled,

—

Total 3 guns.

Battery Wagner (2 companies)
1 32-pdr., rifled,
1 24-pdr., "
2 32-pdr., S. B.,

—

Total 4 guns.

Cumming's Point Battery
1 10-inch columbiad,
1 8-inch Dahlgren,

—

Total 2 guns,

The grand total for the forts was 69 pieces, including 5 mortars, as against 32 for the fleet.

The *Weehawken* in its advance was compelled to fall back because of the fire it encountered. The *New Ironsides* was struck frequently and after getting within 1700 yards of Fort

Sumter was forced to fall back. The *Keokuk*, which approached within 900 yards of Fort Sumter, was quickly riddled, had its guns silenced, and was, in the end, so badly injured that it sank, as we have seen. The remaining monitors kept up the fight till the order for withdrawal. Of the vessels engaged, four were put out of action. The *Passaic* was so disabled that it had to be towed to Port Royal.

The action lasted about two hours and twenty-five minutes. Most of the ships were at ranges varying from 900 to 1300 yards. The fleet fired 154* projectiles, although one report says 139†, of which 55 took effect in the wall of Sumter.‡ Fort Moultrie and the other batteries were not touched. These forts fired 1399 projectiles, while Fort Sumter fired 810, making in all 2209. Another report gives the total as 2206.

Fleet reports give 520 hits on the ships, while another report gives 439.

Confederate vessels took no part in the action, neither did Federal land forces; the engagement was, in fact, purely a naval attack on Fort Sumter, very few shots being fired at other works, which were practically ignored. The ranges at which other works came into action, however, were:

Fort Moultrie Battery Wagner Cumming's Point Battery	1200 to 1500 yards.
Battery Bee Battery Beauregard	1600 to 2000 yards (too far to do much damage).

Expenditure of Ammunition, etc.

Confederate

(See table at top of page 198.)

Of the guns engaged one-fourth were smooth-bore 32-pdrs. Ranges were reported as from 900 to 2000 yards.

In Fort Sumter one 10-inch gun was disabled and two rifles were dismounted by naval fire, and one 8-inch gun burst; while the damage to the masonry was considerable. On the exposed fronts were the marks of some 55 hits; four embrasures were injured and two destroyed; a section of parapet on the eastern flank was breached and loosened for some 25 feet, a part of the

* See *Official Records of the Union and Confederate Armies*, Series I, Vol. XIV, pages 243-244.

† Johnson's "*The Defense of Charleston Harbor*," page 57.

‡ For detailed report of damage to Fort Sumter, see *Official Records of the Union and Confederate Armies*, Series I, Vol. XIV, page 216 et seq.

Works	Guns engaged	Shots fired	Casualties
Fort Sumter*	33	810	5 wounded.
Fort Moultrie	21	868	1 killed by falling of flagstaff.
Battery Bee	6	283	None.
Battery Beauregard	3	157	None.
Battery Gregg	2	65	
Battery Wagner	4	26	3 killed, 5 wounded by accidental explosion.
Total	69	2209	

* East and northeast faces.

parapet falling out and exposing the gun behind it; a scarp wall was penetrated, etc. But, on the whole, the work had scarcely lost any of its fighting capacity or real efficiency.

After the fleet left, Fort Sumter was further strengthened; its armament was shifted about to give more effective fire; the damages of the late action were repaired; a heavy traverse of sand bags was run along the barbette battery; all casemates on the sea front, both upper and lower, were filled with sand; and the upper magazines were abandoned and the arches of the lower ones were filled up.

Federal

Vessels	Guns	Shots fired	Hits received	Casualties
Weehawken	2	26	53	None.
Passaic	2	13	35	"
Montauk	2	27	14	"
Patapsco	2	10	47	None
New Iron Sides	8	8	93	"
Catskill	2	22	20	"
Nantucket	2	15	51	"
Nahant	2	15	36	1 killed, 6 wounded.
Keokuk	1	3	90	16 "
Total	23	139	439	1 " 22 "

Ranges were reported as from 500 to 2000 yards. The vessels passed by Fort Sumter on the course of an ellipse. The distance between the attacking vessels was 300 yards. Turrets were fired at 10-minute intervals.

OPERATIONS OF THE SUMMER AND AUTUMN OF 1863

After the repulse of April 7th, the idea of any further direct ironclad attack was given up, and the idea of a combined military and naval attack was again considered. The military forces waited some two months for the fleet to get ready, and then another month was spent waiting for a successor to Admiral Dupont, who was subsequently relieved by Admiral Dahlgren. During this time the works on James Island were further improved; Fort Sumter was, as just mentioned, repaired; and it, as well as other works, was further strengthened.

In abandoning operations after the repulse that had just occurred, the Federal forces continued to occupy and control Stono Inlet and the whole of Folly Island, where some 5000 troops were. Strong works were built at its southern end and some about two miles from the north end; roads were built communicating with all parts of the island; and a naval force of two gunboats and a mortar vessel was stationed in Stono Inlet and Folly River, in cooperation with the Federal troops.

While Federal pickets were at Little Folly Island, the northern extremity of Folly Island, Confederate pickets were at Lighthouse Inlet, some 500 yards across. Confederate field works were on the southern end of Morris Island and a desultory fire was opened on the Federal troops, who, however, made no reply, as the Federals at that time (June 1863) were busily engaged building batteries only 1000 yards distant, entirely out of sight of the Confederates.

Meanwhile the number of Confederate troops available for duty was being gradually reduced, many being sent to join the field armies. On July 10th, there were said to be but 5861 in the First Military District, guarding the fortifications about Charleston.

On June 12th, 1863, Brigadier General Q. A. Gillmore took command of the Federal forces in the Department of the South and on July 6th of the same year Admiral Dahlgren succeeded to the naval command. General Gillmore decided to make Stono Inlet his base, which was some ten miles distant by air

line from Charleston, but considerably further in distances that had to be traversed. Here were concentrated some 10,000 infantry, 350 artillery, and 600 engineer troops.

The operations about Charleston Harbor that took place in the summer and autumn of 1863 included:*

1. Descent upon and capture of the Confederate fortified positions on the south end of Morris Island.

2. Two unsuccessful assaults upon Fort Wagner, July 11th and 18th.

3. Demolition of Fort Sumter by two bombardments, from August 17th to 23rd, and from October 29th to November 9th, respectively.

4. The siege and reduction of Forts Wagner and Gregg ending September 7th, 1863.

Landing on Morris Island

In general terms, it may be said that the plan was to make a descent from Folly Island upon the southern end of Morris Island with the object of advancing on Fort Sumter in order to reduce it in cooperation with the Navy.

Against the detached and unfinished works of the Confederates, there were in place on July 10th some 47 guns and mortars; while the Federal land force comprised nearly 2000 men, with another 1000 in reserve, and the Federal naval support comprised four armed launches and four monitors in the channel, ready to take part as soon as the attacking batteries on Folly Island should be opened.

The Confederate force on Morris Island at this time consisted of two companies and a detachment of artillery at the southern end supported by 450 men, a total of less than 700; and, at the northern end, two companies in Fort Wagner and one in Battery Gregg, making a total force on the island of 927 men.

On James Island the Confederate total was 2906, and on Sullivan's Island, 850; making a grand total of about 5000.

After several delays, the descent on Morris Island was made on the morning of July 10th,† and the landing and advance were successful.

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* For details of the scheme proposed for taking Charleston Harbor, see *Official Records of the Union and Confederate Armies*, Series I, Vol. VI, pages 227-235.

† For a sketch showing the appearance of the batteries on Cumming's Point, Morris Island, see Plate II, Atlas, *Official Records of the Union and Confederate Armies*.

The monitors assisted the Federal forces very considerably, firing in all some 3034 projectiles upon the island, though in return they were often hit themselves—especially the *Catskill.*

By 9:00 A. M. the Federal forces held three-fourths of the island and were within musket range of Fort Wagner, upon which the Confederates, as they were driven back, retreated. The engagement lasted about three hours, and at its conclusion the Federals held the whole island, except about one mile at the north end, which mile included Fort Wagner and the batteries at Cumming's Point, a total of fourteen or fifteen guns.

General Beauregard states in his contribution to *Battles and Leaders of the Civil War*, Vol. IV, page 14, that the Federal success in landing on Morris Island was due to the insufficiency of the infantry force and the incompleteness of the batteries on the island.

Assaults on Fort Wagner

An assault was made the next morning against Fort Wagner; but it failed, although the Federal troops had gained the parapet of the work. The Federal loss here was about 150 killed and wounded; while the total Confederate loss on the island up to and including the time of this assault was about 300.

Fort Sumter fired upon the Federal positions on Morris Island for several days, it being estimated that more than 1000 projectiles were used.

As the result of the operations so far carried out, the Confederates held about one mile of the northern part of the island, with two strong works, while the Federals held nearly three miles of the southern part.

During the operations on Morris Island a diversion had been made on James Island by Federal troops, and those troops were not withdrawn till Jully 17th.

Immediately after the failure of this assault, General Gillmore decided to construct batteries for the reduction of Fort Wagner; so such works were begun on the night of July 12th, four batteries being built about 1300 to 2000 yards from the fort, mounting in all 41 guns and mortars.

Another assault was made at twilight July 18th, and it also failed.

A siege was now determined upon, as the work was found much stronger than had been anticipated; and it was further decided to demolish Fort Sumter by the use of breaching

batteries, which could be erected on ground already in possession of the Federals. So Parrott rifled guns (100-, 200-, and 300-pdrs.) which could shoot 4000 yards and more were brought to Morris Island and set up, and were ultimately used in action against Fort Sumter.

Fort Sumter

From Fort Sumter, guns were being withdrawn and sent to new works on James Island, altogether some 20 guns and mortars (those mounted in barbette on the left flank of the fort and some mounted in casemates) being removed. By the end of July, the armament of the fort consisted of 38 guns and 2 mortars.

The armament, thus reduced, remained up to the opening of the first bombardment in detail as follows:

Left flank barbette (western): 2 9-inch Dahlgrens.

Left face barbette (northwestern): 2 10-inch columbiads; 2 8-inch columbiads; and 4 42-pdrs.

Right face barbette (northeastern): 2 10-inch columbiads; and 5 rifled and banded 42-pdrs.

Right flank barbette (eastern): 1 9-inch Dahlgren; 4 10-inch columbiads; 1 8-inch columbiad; 1 42-pdr., rifled; and 1 7-inch Brooks rifle.

Gorge barbette: 5 rifled and banded 32-pdrs., and 1 24-pdr.

Parade: 2 10-inch mortars.

Salient, second tier casemates: 3 rifled and banded 42-pdrs.

Lower tier casemates on right and left faces: 2 navy 8-inch and 2 32-pdrs.

The gorge was further strengthened by the use of wet bales of cotton packed with sand; merlons and traverses were built to protect the barbette battery on the right flank: and some 20,000 bags of sand brought from Charleston were used for the protection of the sally-port and the western half of the gorge scarp, the latter being covered up to a height of some 25 feet, though not completed, due to lack of both material and time.

The Confederate engineers had some 350 to 450 men working day and night for six weeks and converted the two faces of Fort Sumter nearest Morris Island into a compact massive redan of sand encased with brick, having a general thickness of 25 feet, and, at the gorge, a thickness of some 35 to 40 feet.

Siege Operations on Morris Island and Bombardment of Fort Sumter

Reverting now to the Federal operations in detail,* we learn that the first parallel was run July 13th some 1350 yards in front of Fort Wagner, and that on July 18th after a bombardment from some 41 siege and field guns and from six ironclads, which brought into action some 70 guns at an estimated rate of fire of 14 shots per minute, the assault already mentioned was made.

The loss incurred in the assault was 1500 killed and wounded, for the Federals, and 174 killed and wounded, for the Confederates. The force holding Fort Wagner was 1000.

On the 20th the attack was continued, some eight shots being fired at Fort Sumter from the 30-pdr. Parrott rifles of the first parallel at a range of 3500 yards. These were the first shots fired at Fort Sumter from a land battery on Morris Island. No serious damage was done, although a 10-inch gun was dismounted.

On the night of the 23rd the second parallel, some 870 yards from Fort Wagner or 500 yards in advance of the first, was commenced, use being made of a flying sap.

On July 25th some six shots were fired at Fort Sumter at a range of 4300 yards. The *Ottawa* and two other gunboats also engaged Fort Wagner.

The third parallel was established August 9th and was some 330 yards in front of the second.

From about July 28th to August 17th the bombardment of Fort Wagner was kept up, the naval squadron engaging at various times.

In the meantime, as has been already stated, General Gillmore was building heavy breaching batteries, the first gun of those batteries being fired August 12th, after which date what was practically a ranging practice was engaged in for some time. Fort Sumter, at this time, was firing slowly both day and night upon the Federal works in front of Fort Wagner.

The Federal breaching batteries and positions were as follows:

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* For detailed account of assaults on and capture of Fort Wagner, see Gillmore's report in *Official Records of the Union and Confederate Armies*, Series I, Vol. XXVIII, Part 1, pages 1-40.

	Dist. from Sumter	Armament	Location
Battery Brown	3516 yds.	2 8-inch Parrott rifles (150-,200-pdrs.)	On right, 2nd parallel near beach.
Battery Rosecrans	3447 "	3 100-pdr. Parrotts	On left, 2nd parallel.
Battery Meade	3428 "	2 100-pdr. " 2 8-inch Parrott	On left, 2nd parallel in front Rosecrans.
Naval Battery	3980 "	2 80-pdr. Whitworths	Center of 1st parallel (manned by sailors).
Battery Hayes	4172 "	1 8-inch Parrott 1 8-inch "	On creek 300 yds. of Beacon House.
Battery Reno	4272 "	2 100-pdr. Parrotts	On creek 135 yds. west of Battery Hayes.
Battery Stevens	4278 "	2 100-pdr. "	Left of Battery Reno.
Battery Strong	4290 "	1 10-inch Parrott	Left of Battery Stevens.

In all, there were

2 80-pdr. Whitworth rifles,
9 100-pdr. Parrott,
6 200-pdr. Parrott,
1 300-pdr. Parrott,

or 18 rifled guns in eight batteries throwing approximately in the aggregate a ton of metal at each discharge.

These batteries bombarded Fort Sumter for seven days, from August 17th to 23rd; while the fleet, from several vessels, kept Fort Wagner under fire.

Collecting the data* from various sources, especially from Johnson's *The Defense of Charleston Harbor*, we have the following table:

Day	Guns firing	Shots fired	Fell Outside	Fell Inside	Fell Over	Shots fired by Ft. Sumter	Casualties
1st	11	948	445	233	270	64†	1 man killed, 14 wounded.
2nd	14	876	452	244	180	Not given.	3 men wounded.
3rd	15	780	241	408	131	Several.‡	1 man killed; 4 wounded.
4th	18	879	241	408	131		3 slightly wounded.
5th	18	943	320	430	193		2 men severely wounded; 4 men slightly.
6th	18	604	216	203	185	6‡	None.
7th		651‖	230	220	204		5 wounded.
	18	633	210	282	141		6 wounded.

* For a detailed account of shots fired, see *Official Records of the Union and Confederate Armies*, Series I, Vol. XXVIII, Part 1, page 23.

† Fired at squadron of 1 monitor and 4 gunboats; no observable results.

‡ Fired at vessels off Fort Sumter at various times.

‖ Includes the night firing of August 22nd as well as shots fired by the monitors.

The bombardment began at 5 A. M., August 17th, and was said to have been remarkably accurate, its effects being severe. On the first day the parapet of the gorge was more than half demolished; the second and third stories of the west barracks, except a portion under cover of the gorge, were reduced to ruins; and seven guns in barbette were disabled. After the first day's battering the ruin of Fort Sumter, as a closed brick fort, was a foregone conclusion, being merely a question of time; so it became the duty of the defense to delay the demolition as long as possible and to save all material of war. Accordingly, on the first night a large quantity of ammunition and stores were removed from the fort to Sullivan's Island.

On the second day more damage was done, additional guns being disabled, including two 10-inch columbiads on the right face; arches being broken down; etc.

On the third day the scarp of the gorge was breached; four upper and three lower embrasures were more or less shattered; and more guns were disabled.

On the fourth day a clear breach, 8 feet by 10 feet, was made in the wall of the upper casemates, the first considerable breach of the bombardment.

On the fifth day more guns were disabled, one 10-inch and one 8-inch columbiad on the flank, together with two rifled 42-pdrs., and the parapet was further disabled. On this day, also, additional powder was removed.

On the sixth day, the 7-inch Brooks rifle was disabled, and later a 10-inch columbiad and rifled 42-pdr.; so only four guns were left in a serviceable condition, and of those only two were in action, an 11-inch Dahlgren taken off the *Keokuk* and a 10-inch columbiad.

On the night of August 22-23, a night attack was made by monitors.

On the seventh day the parapet was badly shattered and only one gun, the 11-inch Dahlgren, remained in good condition —Fort Sumter was practically demolished, but not yet silenced.

The Navy, during this time, also was in action, though its target was mostly the batteries on Morris Island—generally Fort Wagner.

On the first day, or the 17th day of August, seven ironclads and seven gunboats engaged Battery Gregg and Fort Wagner, the latter replying for over an hour with three guns.

On the next day, the 18th, the fleet had three ironclads and five gunboats in action against Fort Wagner. From the

New Ironsides, during these two days, some 805 shells were fired.

During the next few days this fire was continued; and on the night of 22nd-23rd an attack by five monitors was made against Fort Sumter—50 shell being fired in the direction of the western magazine.

On the 21st of August, the infantry made another unsuccessful assault on Fort Wagner. Subsequently, another parallel, the fourth, was commenced, about 300 yards from Fort Wagner; and another assault made on the 25th failing, a fifth parallel was commenced, bringing the Federal lines 240 yards from the fort. Guns were now brought up and the work was heavily bombarded, and an assault was ordered to be made on the morning of September 7th. The Confederates, however, evacuated the work and Battery Gregg also on the night of the 6th, and so quickly and so quietly was this done that only 70 men were captured. Some 18 guns were found at Fort Wagner and 7 at Battery Gregg. The entire island was now in the hands of the Federals.

In the bombardment of Fort Wagner, the Federal land batteries threw 1663 rifle projectiles and 1553 mortar shell, while the *New Ironsides* threw 488, making a total of nearly 4000 in forty-two hours, to which Fort Wagner was subjected.

The ammunition thus far fired in the Federal operations included over 6000 projectiles fired by the land batteries against Fort Sumter and 9875 fired by the land batteries and the fleet against Fort Wagner, a grand total of about 16,000.

The second period of the bombardment of Fort Sumter may be said to have extended from the 24th of August to the 2nd of September, during which time, as far as the breaching batteries were concerned, the fire was greatly reduced; though a naval attack was made on the fort during the night of September 1st-2nd.

During these nine days the demolition of Fort Sumter was greatly increased, particularly by the firing of the 300-pdr. Parrott rifle, upper casemates being tumbled down onto the terreplein, bringing with them guns, platforms, etc. Also, guns and ammunition were being taken out of the work, some 25 guns and mortars being thus moved; so ultimately the artillery troops were relieved and their place taken by infantry.

The naval attack made against the fort on the night of September 1st-2nd, was made by six monitors at a range of 700-1500 yards, and by the *New Ironsides* at 1500 yards. This action lasted about five hours, during which time the

squadron fired 245 shots. The east wall of Fort Sumter was much battered by the ships' guns, every casemate on that side, both upper and lower, being breached. The batteries on Sullivan's Island returned the fire, and the squadron was hit 71 times. There was no reply from Fort Sumter, there being now not a single gun left to fire in its defense.

Notwithstanding the fact that in the first bombardment of Fort Sumter there were, in round numbers, 6000 projectiles fired and in the second, 1819, yet the total casualties in the fort incident to both bombardments were 2 killed and 50 wounded.

Surrender of Fort Sumter having been refused when first demanded, on August 21st, on September 7th another demand was made, and again it was refused.

Bombardment of Fort Moultrie and Fort Sumter 1863-1864

The Navy now turned its attention to Fort Moultrie, attacking it on the 7th of September, when two guns were dismounted; but other damage done to the fort was slight.

On the night of the 8th, an assault was made on Fort Sumter, but was a complete failure.

The next period of bombardment may be said to have extended from September 9th to December 6th. Soon after the capture of Fort Wagner and Battery Gregg, additional batteries were built, providing in all 29 large guns and mortars to fire on Fort Sumter (2 13-inch mortars; 14 10-inch mortars; 12 Parrott 100-,200-, and 300-pdr. rifles; and 1 10-inch columbiad) and some smaller rifled guns, such as 30-pdrs.

About this time, there was installed by the Federals on Cumming's Point a calcium light, which gave very satisfactroy service, being a great aid to the Federals in night bombardments, as well as a great hindrance to the Confederates making repairs at Fort Sumter. This light was strong enough to light up Fort Sumter brilliantly, it being said that newspapers could be read in the fort by its light.

On September 28th was begun a minor bombardment, which lasted about six days, the total number of shots fired being 567 and the casualties one killed and one wounded; the damage done the fort was hardly perceptible.

About this time a three-gun battery (2 10-inch columbiads and 1 42-pdr.) was mounted on the four lower casemates of the northeastern front, next to the eastern angle, in embrasures of palmetto logs, thus making it possible to cross fire

with the batteries of Sullivan's Island bearing on the channel and guarding obstructions. Although its guns were never brought into action, this battery was an effective adjunct to the defense of the channel.

On October 26th began another bombardment, in which two of the monitors cooperated with the land batteries. This bombardment lasted some forty-one days, to December 6th, but with varying intensity, the heaviest firing occurring in the first week or ten days, on each of two days more than 1000 projectiles being fired at the fort.

The general result of this fire, during which night firing was kept up with vigor and mortar fire seemed to predominate, was less than that of the first bombardment. However, the walls of the fort were being further cut down by it, especially along the gorge, forming slopes of débris both on the inside and on the outside of the work, and ultimately making a practicable slope for assault. On October 31st, at 3 A. M., the upper floor of a casemate was brought down by a shell, 13 men who were sleeping in the casemate being killed.

Several small reconnoitering parties made up of Federal forces landed on the work, but were quickly driven off; and on November 20th a demonstration was made by some 250 men in barges, in an attempt to ascertain the strength of the garrison still holding Fort Sumter.

About the beginning of December the bombardment gradually died down, on December 6th, for the first time in forty-one days, not a shot being fired; so the second bombardment was ended.

The variation in intensity of the bombardment is shown in the following abstract* of ammunition expended by the Federals, in which are given also the Confederate casualties.

Date		Projectiles	Casualties
October	26	188	1 wounded.
"	27	625	—
"	28	679	—
"	29-31	2961	33 (incl. 13 killed by falling floor).
November	1	786	1 wounded.
"	2	793	1 killed.
"	3	661	7 wounded.

* Taken from Johnson's *The Defense of Charleston Harbor.*

Date		Projectiles	Casualties
November	6	(not reported)	2 killed, 12 wounded.
"	7–10	1753	9 wounded.
"	11	219	1 wounded.
"	12–15	2326	2 killed, 5 wounded.
"	16	602	—
"	17–18	959	1 killed.
"	19	694	1 wounded.
"	20	1344	3 killed, 11 wounded.
"	24	270	3 killed, 2 wounded.
"	25-26	517	—
Nov. 28-Dec.	4	1307	1 killed, 1 wounded.
"	5	61	

The total number of shot and shell fired by rifles and mortars, including the fleet's fire, was 18,677. The Confederate casualties were 30 killed and 67 wounded, including the 13 spoken of as crushed under a falling floor.

At the end of the second bombardment, the condition of Fort Sumter was as follows: the sea face, or right flank, of the work had lost the greater part of the upper casemates; débris formed large accumulations both inside and outside the fort; from its original perpendicular form, forty feet high, the wall was changed to an irregular mass of rubbish averaging about twenty feet above the tide, and showing a rugged crest of about six feet width; the lower casemates still filled with sand formed the bulk of the remaining barrier; the angles of the fort still retained the level of the old terreplein.

During the latter part of December only a desultory fire was kept up against the fort with some 30-pdr. rifles at Cumming's Point and some mortars in the "middle" battery.

A minor bombardment lasting from January 28th to February 1st occurred, wherein some 583 projectiles were fired. The damage done was slight. There were still other minor bombardments—one on March 15th and another on April 3rd—but the results were nominal.

Fort Sumter by this time had been converted into a formidable earthwork, with a garrison of 300 men, constituting a strong outpost.

FINAL OPERATIONS AGAINST FORT SUMTER, MAY, 1864, TO FEBRUARY, 1865

At about this time there were changes among the commanders, and General Gillmore, after ten months service, left for a more active theatre of war. Major General Foster, who was formerly a captain of engineers at Fort Sumter under Major Anderson, was sent to take his place.

The naval force remaining of the same strength, an iron-clad squadron of eight vessels, Admiral Dahlgren convened a board of his captains May 10th to 12th to consider the advisability of attacking the remnant of Fort Sumter, and by a vote of 7 to 2 the decision was against it. Consequently, nothing but feeble demonstrations were made, on May 13th, 14th, 15th, and 16th, two monitors, in conjunction with land batteries on Morris Island cannonading Fort Sumter, and lighter guns keeping up the fire at night. In the four days, some 1140 shots were fired, and the Confederate casualties were one killed and four wounded. Not much damage was done. This was the last occasion of any fire from the monitors upon Sumter.

In June, 1864, the *New Ironsides* went north, which left but seven monitors, and two of those were out of order. Opposed to them, however, were only three Confederate gunboats.

Another minor bombardment occurred May 30th to June 5th. There were four casualties, but no damage to the fort.

Near the end of June a concerted movement having for its object the capture of Fort Johnson and Battery Simkins on the James Island shore of Charleston harbor was planned and attempted, but failed, resulting in a Federal loss of 330, while the total Confederate loss was 163, of which 17 were killed.

The third great bombardment of Fort Sumter was now begun on the morning of July 7th, at, 5 A. M., the fire being directed principally against the gorge; and within a week the work was breached in three places and reduced at one point to a height of only twenty feet above the water. The most destructive work was done by the 300-pdr. The average daily expenditure of ammunition during the first week was 300 shot and shell.

During the second week, the expenditure of ammunition increased, reaching nearly 500 a day; and at the end of the week the Confederate casualties amounted to six killed and twenty-six wounded. Captain Mitchell, commanding Fort

Sumter, was included among the killed, as a result of being struck by a fragment of a mortar shell.

This bombardment was replied to by the batteries of Sullivan's Island; but, on account of a shortage of ammunition as well as of the little effect produced, they soon ceased firing.

The third bombardment lasted some sixty days, at the end of which time, on September 19th, the Federal commander reported, "Fire stopped for want of ammunition."

No firing upon the fort, but such as may be termed desultory, occurred after September, 1864, military interest in the defense of Fort Sumter ending with the close of the third grand bombardment.

THIRD BOMBARDMENT

Ammunition Expended and Casualties

	Shot and shell fired	Casualties
July (from 7th)	8680	8 killed, 40 wounded.
August	5772	5 " 22 "
September (to 7th)	214	3 " 3 "
	14666	16 " 65 "

Movements in other spheres now dominated the Federal movements in front of Charleston, where the policy of the Federal forces became wholly defensive.

Firing almost entirely ceased, except for a slow and irregular fire upon the city at extreme range; and during the remainder of September, 1864, and through October and November, firing became more and more desultory, averaging about 30 shots per day; until at last, in December, when the march of General Sherman upon Savannah called for the cooperation of the Federal forces, both naval and military, before Charleston, Fort Sumter had practically entire respite from the Federals, only seven shots being received in December, sixty-four in January, and none at all in February. The fort had, in fact, silenced the very guns which had once silenced it.

No less than 51 rifled cannon were worn-out or burst in firing from Morris Island—24 under Gillmore and 27 under Foster.

In February, 1865, a change in the Federal commander before Charleston was again made, General Gillmore relieving General Foster on February 9th.

On the 16th of February the commander of Fort Sumter received orders to prepare to abandon the fort at once; so some 300 officers and men evacuated the work during the night of February 17th, leaving it intact, according to instructions. And, it becoming known early the next morning that the city had been evacuated, the fort was soon occupied by Federal troops, 250 guns falling into their hands.

The defense of Fort Sumter was ended.

Comments

1. Between April 17, 1863, and February 17th, 1865, the fort was actually under fire some 280 days, and the casualties in it incident to the bombardment were 267. The weight of metal thrown, Johnson estimates as 3500 tons, of which some 2400 tons represent the weight striking the fort.

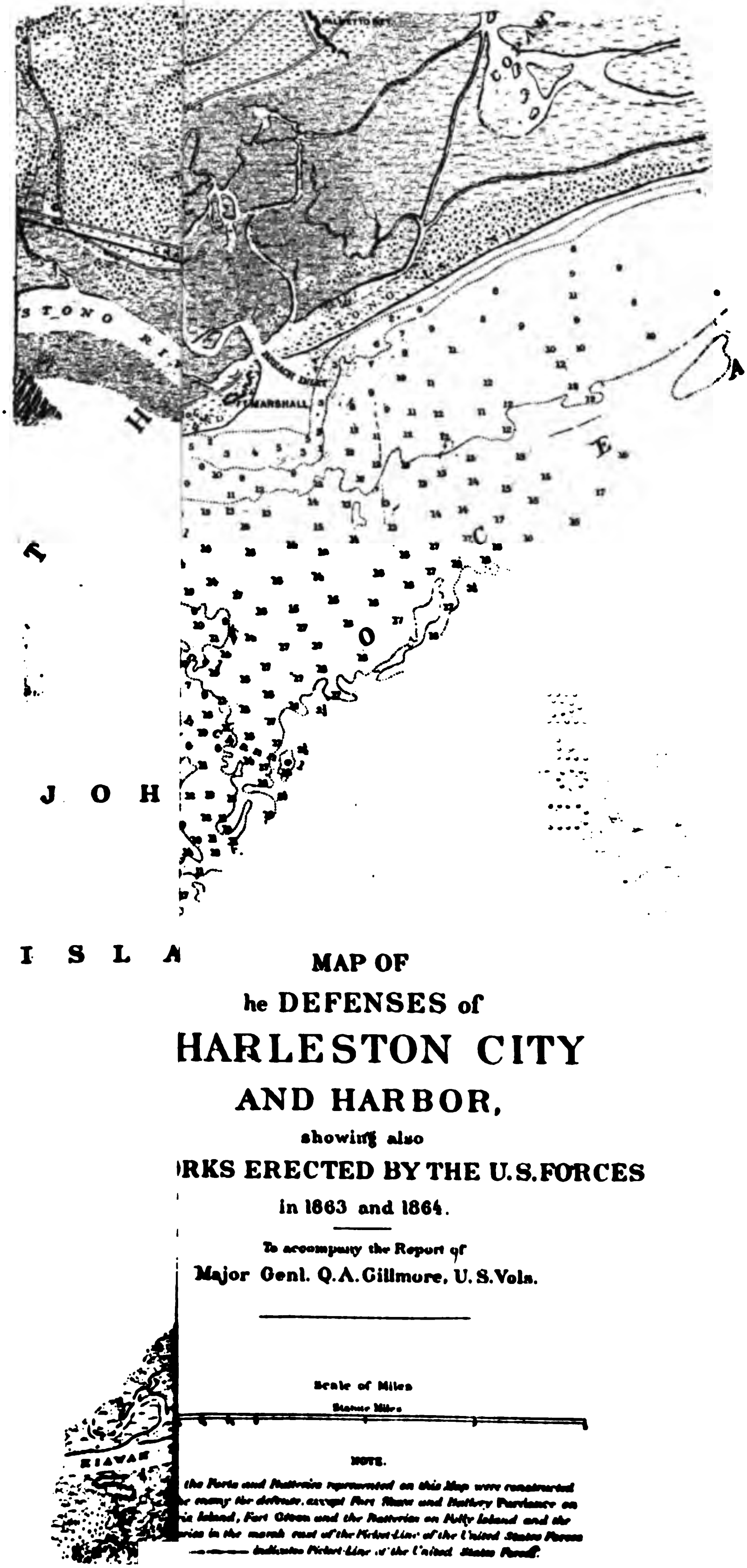
2. We see in this struggle full use made of all means of offense and defense—armored vessels, breaching guns, and harbor obstructions, including torpedo devices.

3. Fort Wagner was but an outwork and should have been at the southern end of the island; it was lost because the attacking troops once obtained a foothold on the island on which it was located. Another example, only on a larger scale, of the affair at Roanoke Island in 1862. Moreover, the defense of Fort Wagner was too passive, no attempts being made to drive the Federals off and no advantage being taken of the use of mortars for rendering the Federal siege operations difficult.

We see again lack of cooperation between military and naval commanders, due to lack of understanding of each other's functions.

5. The old maxim is still true: "Forts cannot withstand a competent land attack, but are able to resist and repel vessels."

Many more lessons may be drawn here, this defense repaying ample study. Its material is readily available and a detailed Confederate account is in existence. A veritable diary of the defense, *The Defense of Charleston Harbor, 1863-1865*, was written by Major Johnson, the engineer officer in charge of the defenses, and is a work which must be included in any serious study of the subject.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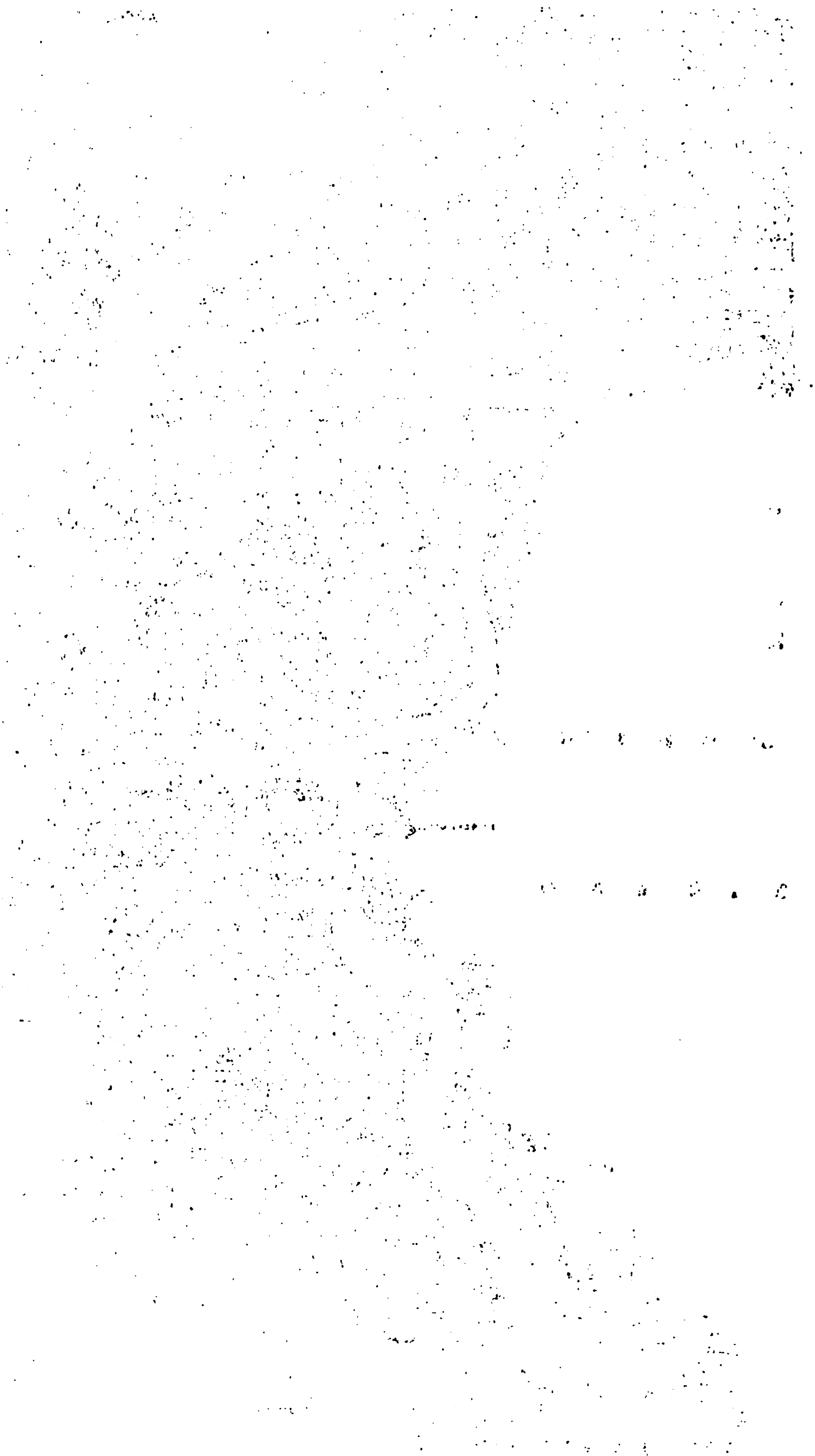
MAP OF
he DEFENSES of
HARLESTON CITY
AND HARBOR,
showing also
RKS ERECTED BY THE U.S.FORCES
in 1863 and 1864.
To accompany the Report of
Major Genl. Q.A.Gillmore, U.S.Vols.
Scale of Miles
NOTE.



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PROFESSIONAL NOTES

SIEGE WARFARE, ACCORDING TO GERMAN OPINION

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Introduction

The marvelous development in the power of artillery, especially since the adoption of high explosive projectiles, has for some years led many to believe that success in siege operations will depend principally upon acquiring a decisive superiority in an artillery duel between a fortress and its attackers. And, considering the great majority of forts now actually in existence, it is thought it might be possible to obtain a fairly prompt and decisive effect by employing a superior mass of artillery consisting principally of guns using curved fire.

Such ideas have prevailed in Germany for several years, where, since their great victories of 1866 and 1870, the greater number of authors had made a practice of placing exclusive faith in the methods of warfare to which their surprising success in those years had been principally due. And, notwithstanding the network of fortifications erected on their frontiers by possible enemies, particularly the French, it was still held that it was practicable to open up a passageway for their armies without too great a loss of time, and march straight towards the main hostile force, by equipping their field troops with a large number of guns of medium caliber, organized in such manner as to have the greatest possible mobility.

But in time, even in Germany, a reaction resulted under the influence of their more important authors, who had forced themselves to a more thorough consideration of the factors of success, and under the influence of the progress made in the art of fortification, there being constant development and improvement of permanent forts in all important states. The Germans were further influenced by new political groupings in Europe, and the consideration of the possibility of their having to assume a defensive attitude along one of their frontiers, if only temporarily, while delivering a decisive blow on some other frontier.

The adoption of concrete and armor in forts was of especial importance; for while heavy bombardments, might, by superiority of fire, temporarily silence fortress artillery protected by strong armor, yet, even when undertaken by most powerful batteries, such bombardments would rarely succeed in destroying the armor; in consequence of which, the fortress artillery might reopen fire when the attack was at short range, at the very time when the attacking artillery might have either to cease firing or to increase its range, and in this manner with the assistance of flank guns and rifle fire inflict such

grave losses upon the attack as to cause a failure of even the strongest and most courageously conducted assaults.

The siege of Port Arthur is a striking illustration of what the capture of a fortress may cost, when bravely defended, even if not completely armed with modern equipment. As a result of that siege, practically all nations revised their regulations on fortress warfare, seeking to profit as much as possible from the lessons learned. And in Germany, perhaps more than in other states, there was felt the need of giving to fortifications and siege warfare, by filling in the gaps existing in their current instructions, the consideration which they really demanded. But in doing this, the Germans never forgot the principle, always respected by them, that field warfare against the enemy's army is the essential and decisive factor in war. Following that principle, Germany has built its most recent fortresses as true assembling points on the frontier, where troops may be mobilized in security from hostile interference, with a view to subsequently proceeding boldly to the invasion of the enemy's territory.

In the current German regulations on siege warfare, care has been taken to explain in the introduction that the principal object of war is the destruction of the hostile army, and that every possible means must be employed to effect that result; that fortresses must not be defended or attacked for themselves alone, but only in relation to the operations of the field army, and that such fortresses are means like any other at the disposition of the commander-in-chief. This fundamental principle is also found in the "Guide for Tactics" of the German War College of 1910, in which it is laid down that future wars will be decided in open campaign; that the destruction of the enemy's army should be the supreme mission of the commander-in-chief; and that, consequently, the importance of fortified places is measured principally by the influence which they exert on field operations.

This same idea appears throughout all the rules laid down for siege warfare, not only as a general principle, but also as far as possible, in methods of execution. In fact, the instructions already referred to on siege warfare, state that fighting about fortresses is usually the result of field operations, which gradually change into a struggle for the possession of the fortified place assisted by powerful artillery and modern resources. This requires more thorough preparation and more time than is necessary for field operations; but for both field and siege operations the general principles remain the same. It should be noted that this conclusion agrees practically with analogous conclusions reached in nearly all other armies.

But while this opinion has been reached in the majority of armies and has resulted in the rules for field warfare gradually losing the special characteristics which up to now they have had, the Germans, on the contrary have taken an opposite course. They had for some time given little attention to fortifications and consequently to siege warfare, and had held that it was sufficient to employ in such operations field units reenforced by suitable artillery, but now greater study is being given to this subject. In doing this, however, the Germans have remained constantly faithful to the idea that fortress warfare must be strictly subordinated to field operations, of which they should be but an incident, to be undertaken only when necessary for the success of some field movement, and like them retaining as far as possible the characteristics of boldness and celerity.

Following this train of thought on siege warfare, differing from and in part opposed to the prevailing thought in other armies, the Germans derive

from the normal principles laid down by them certain special requirements, which we now propose briefly to review.

The Attack

An examination of the German formations for sieges indicates that their organization is based on the theories already mentioned—aggressiveness, quick resolution and celerity of movement.

A characteristic of their formations is the great abundance of means provided, and especially of transportation, with a view to promptly reenforcing any field unit charged with a siege with a large number of medium caliber batteries, completely provided with everything necessary for their separate organization, so as to make possible prompt and efficient action on their part.

Thus, many battalions of fortress artillery have a complete equipment of draught animals; the 6-inch howitzers and the 8.2-inch mortars, for example, are organized as heavy field artillery and assigned in considerable numbers to army corps. Each corps has a battalion of four 4-gun howitzer batteries, and in addition each army will have a certain number, not yet exactly determined, either of 6-inch howitzer battalions, organized as above, or else a battalion of two 4-gun 8.2-inch mortar batteries.

Such liberality in means of attack is possible in Germany, on account of the large number of animals existing in that country, and also on account of their thick network of railways.

To each battalion of fortress artillery there is assigned an ammunition company, which provides not only ammunition but also spare supplies, and, to assist in furnishing the same, has as part of its equipment a narrow gauge railway 4.7 miles (7.5 kil.) long, using animal traction.

Each such ammunition company has, in addition, a detachment of mechanics, who relieve the batteries of much work; and, besides, it has been found that by keeping the same men constantly busy at the same kind of work, they become more proficient and render better service than do men temporarily employed on several different kinds of work. All this, naturally, tends to the prompt carrying out of operations.

But where the idea peculiar to Germany most clearly manifests itself, is in the organization of the headquarters of the siege operations, where there is given a very considerable degree of independence and wide authority to commandants of sectors.

To each sector is assigned a complete field unit,* and the best troops are detailed in the sectors selected for assault.

The commandant of the field unit is the commandant of the sector, and commands, not only his own troops, but all special troops assigned to the sectors. For though there is an artillery commander for the siege artillery to assist the commander-in-chief, yet, after making the necessary reconnaissances, he is charged only with advising as to the general distribution of the siege artillery among the various sectors. The employment of medium caliber batteries is left entirely to the sector commandants, through their own artillery commanders, and the commander for siege artillery limits himself, during the attack, to reenforcing the local sector artillery, as may be required, by drawing on units in reserve, or newly arrived, or by transferring artillery found to be in excess in one sector to another sector. For this purpose, the

* Division or corps.—Tr.

siege artillery is organized into battalions and regiments, and to those units are given whatever is necessary to make them independent of other organizations, so that they may be assigned to any sector whatever. Similar methods are employed in the assignment of engineer troops and parks.

The French regulations differ from the German in that the control of their medium caliber artillery is directly exercised by the commander of the siege artillery, the sector commandants controlling all troops in their sectors other than the siege artillery.

Which of these two systems is preferable? In my opinion the German.

At the beginning of operations, when the general lines and the plan of attack must be determined, and troops and accessories assigned to sectors accordingly, there should be determined for each sector the object to be attained, and in this the duties of the commander of the siege artillery will be of the highest importance. But this done, it would appear to me that, during the development of the siege, the greatest liberty should be left to sector commandants as to the methods to be employed, these officers having each his own commander of artillery as an authoritative and capable adviser, who acts in the same manner as a chief of artillery for an army corps, though with even greater responsibility because of the greater importance of artillery action in siege warfare. While the coordinating influence of the commander-in-chief of the siege operations should certainly continue throughout the siege, yet his action should, in my opinion, be limited to matters of a general nature. For in fortresses of importance requiring a division of the attacking forces in sectors, the front selected for an attack will as a rule be so extensive, being certainly larger than would be the case in field operations between forces of similar strength, that it will be more difficult for commanding officers to regulate the movements of the elements.

Moreover, the action of siege artillery will not be limited in its object only to firing against targets situated in its own sector, but will include assisting the infantry advance, first by driving in observation posts and advance troops in order to facilitate the occupation of suitable terrain for the attack, then by assisting in the gradual advance of the attacking troops, and finally by assisting in the assault. It is believed that, in the majority of cases, the occupation of ground, rather than distant fire effect, will have the greater influence upon the defense, so the action of the field troops should be constantly supported by the action of the siege artillery. These two classes of troops should always act in concert, for the objective and successive positions of the siege batteries are intimately associated with the action of the other arms, not only that the batteries may render the other arms the most effective and opportune assistance, in time and direction, but also, in order that both may obtain the greatest possible advantage from joint action. It is obvious that good team work by troops will not only much simplify reconnaissance and observation of targets, but also often enable a cross or combined fire to be brought to bear in such manner as to give a superiority of fire on the targets. Consequently, only sector commanders, assisted by their respective chiefs of artillery, will be in a position to best regulate the employment of the medium caliber batteries, together with all other artillery and troops under their orders; and the coordinating of operations between sectors should, as already stated, be of a very general nature. The best assistance which troops in different sectors can mutually render one another, is by constantly advancing on the enemy, so as either to menace the enemy's

troops in their immediate front, or else by operating indirectly on the flanks of the sector attacked.

The nature of the terrain, of the hostile resistance (which cannot at first be definitely ascertained), and all other considerations, including unforeseen incidents which always have a large effect on operations, point to the advisability of leaving to each sector commander complete freedom in utilizing the forces under his control, so as to permit him to profit by momentary successes, to the end that he may continually press the enemy closer, in accomplishment of the desired object.

This is the reason why I consider the German system, as laid down by current authors, preferable: wherever possible, it applies the same rules to siege warfare as to field operations.

With regards to the various methods of attack of fortified places, we may say that, especially since the experience gained at Port Arthur, the ideas in vogue with many authors up to a few years ago concerning the effectiveness of bombardments and other quick methods, have been considerably modified, it being now generally recognized that, as a rule, a regular siege will be required before a well defended fortress. But this is not to be construed as eliminating the use of other methods when circumstances warrant —particularly when either material defects or, better, loss of morale, exists in the defense; and, even during a regular siege, occasions may arise favorable for the capture of the fortress by surprise, either by direct attack or by bombardment.

The German instructions state that against well organized and energetically defended fortresses, only regular attacks, by joint action of infantry and artillery, can lead to decisive results. And from this we can see what a change of opinion has occurred in that army, where, as Froebenius says, up to a few years ago the prevailing opinion was that siege artillery fire was in itself sufficient to breach works, its effect being such as to render an assault unnecessary.

When and how shall we decide on the direction of the attack?

The German instructions reply to this question that the general plan of attack should be decided on at the very beginning of the preliminary operations.*

As all the incidents of the siege from the very commencement of the investment, such as the laying out of lines of communication, unloading of siege material, etc., depend directly on the selection made for the point of attack, it is evident that it is of the greatest importance to decide this point as soon as possible. And it seems to me that it is quite practicable to do this, when we consider that the studies made and data acquired in time of peace concerning fortresses which might become objectives for various armies, usually contain information of great importance, and that in addition preliminary reconnaissances can be undertaken by selected officers sent ahead with the advance troops, independent cavalry, advance guard, etc., who can to a certain extent complete this information in such manner as to enable the siege commander to come to a proper decision. But the German instructions go so far as to state that even when the situation is not completely clear, there should be no delay in coming to a definite decision. Indeed, to wait until complete reconnaissances can be made, would appear to be an enormous loss of time favorable to the enemy.

* The Italian regulations are the same in this regard.

Certainly a decision as to the selection of the point to be attacked (and here we come to a second part of the question in consideration), must be based not only on the defensive powers of the various faces of the fortress and the conformation of the terrain* in their fronts, which should be such as to admit of proper deployment of the siege artillery, but should be based also on the influence which the fall of the face attacked will have on the ultimate fate of the fortress. Moreover, consideration must be given to the strategical situation and to the means of communication, which should be such as to facilitate the provision of all necessary supplies and accessories. The state of the defensive works will of course not be completely revealed until the attack has actually commenced and often not until it has been pushed well forward, and, therefore, as noted before, we cannot afford to delay our decisions until such points have been exactly determined.† On the other hand, consideration of the points we have noted may cause us, with a full knowledge of the facts, to select a face to attack which may be much stronger than some other front, it appearing that the capture of such a face will have a decisive effect on the result of the siege.‡

There are some who object to deciding on the direction of the attack at the very beginning of operations, on the ground that advantage is lost by failing to conceal our intentions from the enemy, enabling him to provide in advance for the defense of the threatened front. And it should be observed that, considering the enormous preparations required for a siege, the defense might easily deduce, from a mere observation of points of assemblege of material, what the objective of the attack would probably be—especially if aerial reconnaissance was practicable.

In my opinion, however, instead of attempting to conceal our own intentions by delaying preliminary operations, we should, on the contrary, endeavor to expedite them by all means in our power, in order that, in point of time, we may be on an equal footing with the defense, and so prevent his accumulating a superiority of strength over us. A prompt decision as to the direction of the principal attack should certainly tend to accomplish this purpose.

The general plan of the siege and the points of attack having been determined on, the various available forces and material are assigned and a general scheme of operations is decided on. But I consider it unnecessary to determine every small detail, it being better to leave liberty in such matters to commandants of sectors, so that they may conform to the changing circumstances and incidents of the attack, as they successively develop; for the relations of the attack to the defense are constantly changing, requiring adjustment of plans for the employment of troops and siege matériel.

The period of investment is a critical one for a besieging force; and the German regulations, rightly considering this subject, include, among other provisions, one to the effect that the field troops should be reenforced as soon

* At present, as indirect fire is normally used by artillery, it is much less limited by features of the terrain than in times when direct fire was used: and for this reason the nature of the terrain lying in front of fortresses is, so far as artillery positions are concerned, of much less consequence than formerly.

† An example of delay in appreciating the true value of a defensive work is afforded by the siege of Port Arthur, in the case of the Chinese wall, the efficiency of which as a means of defense was not understood by the Japanese until after a bloody repulse.

‡ The Italian regulations on this subject read as follows: "Above all, in determining the direction of the attack, consideration must be given to the effect which the fall of the main works of the defense will have, and how this will influence outside operations. There should be no hesitation in selecting such a direction for the attack as promises the greatest advantages, notwithstanding that greater difficulty and increased sacrifices may be necessary in the attainment of the objective determined on.

as possible by siege batteries equipped with means of draught, and that the enemy should be deprived as far as possible of all means of reconnaissance. Siege batteries equipped with means of draught are intended, together with light and heavy field artillery, to assist the investing troops either in occupying advance posts of the defense or in resisting sorties. In addition, they are intended to drive in observation posts, to destroy balloons, dirigibles, etc. By acting with celerity, they may also, according to the German regulations, succeed in occupying supporting positions, which might later require long fighting to obtain possession of.

Throughout the German regulations there exists the constant idea of boldness and offensive activity, in the conviction that any delay in the operations of investment is an advantage to the defenders, to whom may come, as a result thereof, some opportunity to injure detached troops, while in motion and not yet protected by defensive works nor supported by heavy artillery. From this point of view also it is to be noted how important it is to determine early the point of attack, so that the siege artillery may be in position as soon as possible and in rear of other artillery.

The regulations state that the distance from the enemy on which the line of investment shall be located depends on the terrain and the behavior of the enemy. By bombarding and cutting them off from the fortress, it will be necessary to attack without delay advance detachments with which the enemy may seek to delay the closing in of the attacking force; and as to the defenders' advanced posts, if they are beyond the limits of effective protection from the fortress guns, they should be promptly captured, according to the regulations, in order to increase the difficulty of the enemy's observations, and to assist our own reconnaissances and deployment of artillery by the timely seizure of suitable terrain. The attack on such posts can be facilitated by threatening to envelope them, cutting off the retreat of the garrison from the fortress. If, however, the advanced posts are protected by effective fire from the main position, it will be necessary to delay their attack until the siege artillery is ready to open fire and is sure of its superiority over the hostile artillery. But it may frequently be advisable to bombard advanced posts so as to interfere with observation from them, and also in order to cause damage to the troops or works in the place.

The regulations state that the line of investment should be as inconspicuous as possible, in order not to present favorable targets to the enemy. And, in order to economize forces, the regulations advise employment of obstacles and inundations in sectors not to be attacked, whereas in active sectors works should be so constructed as mutually to support one another.

During the period of investment and also after this period is over, constant reconnaissances should be kept up, in order to determine in detail successive events of the siege.

Where should the first deployment of the siege artillery be made?

Evidently, as close to its targets as possible, in order to obtain from the beginning a considerable effect, and to reduce to a minimum changes of position for the purpose of obtaining more effective ranges.

But the German regulations do not conceal the difficulty of finding such positions, nor if found, of the avoidance of severe losses due to an active and well prepared enemy. On the contrary, the regulations state that, while it is desirable for artillery to be promptly employed at decisive ranges,* it may

* Less than 4000 yards, U.S.F.S.R.—Tr.

often be advisable for the besieging force to make a first deployment at much greater distances, even up to the limit of gun fire. Moreover, by placing a part of the large caliber guns at great distances from the principal position of the defense, the enemy's attention may be drawn from points closer to him, which may then be occupied by other batteries.* In preliminary dispositions for the deployment of the siege artillery, provision should be made for a later advance of the guns.

The German regulations continue that, despite the difficulties of the first deployment, it is desirable that all the siege artillery be from the beginning simultaneously deployed. But such a deployment, on account of the great quantity of matériel and the necessary preparations to be made, will increase in difficulty as the positions selected approach the fortress. Furthermore, in order to make a deployment at not too great a range from the hostile works, it is first necessary to occupy the advanced positions of the defense; and to accomplish this task will, as a rule, require the deployment of some siege batteries. So it is obvious that the simultaneous deployment of the mass of the siege artillery, even when made at considerable distances from the fortress, will be rarely possible.

For these reasons, the Germans foresee a series of deployments, first placing in action the batteries having means of draught and the longest range. These batteries are to take position at such distances from the hostile works as will not too greatly interfere with the effectiveness of their fire, and by suitably utilizing whatever cover the terrain affords are to avoid being overwhelmed by the enemy's fire.

The German regulations continually speak of the great importance of mutual support between the artillery and the infantry, at all stages of the siege. For instance, it mentions the necessity of not exposing the infantry to the fire of the fortress before the siege artillery is in position, and considers it advisable not to deploy the infantry in advance of the line of investment, even when this line is only such a limited distance to the front as to be entirely under the protection of our artillery, which, in turn, should itself be placed but a short distance in rear of the infantry lines. Similar ideas are not found in the regulations of other armies, which, on the contrary, prescribe that the infantry shall occupy positions as far to the front as possible, so as to assure the safety of the artillery during deployment.

As to the distance at which artillery ought to be deployed, it being recognized that the nature of the ground and the construction and armament of the hostile works will be quite different in different sectors, a broad initiative is left in the German instructions to sector commandants, in order to permit them from the very commencement of operations the better to take advantage of favorable circumstances in advancing their siege batteries as near as possible to the fortress. The removal of vegetation from the field of fire, the capture by surprise of some advanced post of the defense, inferior conditions of observation or of fire of the defenders' batteries, may permit more progress in one zone than in another. But the possibility of such progress rarely appears at the beginning of operations, when the general plan for the artillery is decided on: it only becomes apparent as the siege progresses, and then the intervention of the commander-in-chief may embarrass and retard the prompt seizing at opportune moments of advantageous points which the local situation may permit.

* This principle was successfully placed in operation by the Servians in the siege of Monastir in the autumn of 1912. - Tr.

It appears to me preferable for sector artillery commanders, who are on the spot, and who, by a continuous exchange of ideas with their respective sector commandants, keep fully informed of their desires, to provide directly for all changes of position of siege batteries, accordingly as may appear most desirable for the success of their various missions.

As soon as it is deployed, the siege artillery in conjunction with the mobile troops, the two acting constantly in unison with one another, initiates operations against the defenders.

While the main part of the medium caliber artillery should be used primarily against the artillery of the defense, yet the German instructions state that some should act against hostile infantry from the beginning of the attack, whenever it appears necessary to assist the advance of our own infantry, which, preceded by reconnoitering patrols, attempts to occupy suitable locations for our own artillery observing stations, or to interrupt the enemy's means of observation. In this manner, by mutual support, the infantry can profit by an advantage obtained by the artillery to secure a movement forward, while the artillery can assist the infantry advance by the discovery of suitable objects to fire at and by their better means of observations.

All troops in a sector are, under the German regulations, controlled by their sector commandants always; for while the commander-in-chief, indeed, coordinates the action of the different sectors, yet his coordination is limited to seeing that the local troops act in unison in parallel columns. Columns which find their advance relatively easy should profit therefrom to assist the advance of neighboring columns, care being taken by the sector commandants that some troops which may have succeeded in gaining excessive ground to the front with respect to other troops, shall not thereby find themselves in a dangerous position and exposed to counter attacks from the defense. The continuous assistance of all the artillery, including the siege artillery, in close and constant touch with its infantry, results in reducing to a minimum any dangers which may arise from the broad liberty of action granted.

On this subject, the French regulations prescribe that, when the siege artillery has obtained a superiority of fire and the fighting of the advance infantry detachments permits of the occupation of a new and closer position, the commander-in-chief, after receiving the advice of his chief of engineers, and, if necessary, that of his chief of artillery also, shall determine the line to be simultaneously occupied by troops of the different sectors; but in each sector the commandant shall arrange all details.

The difference between these two types of instruction is notable: the French retain their old ideas and methods as modified by technical details; the Germans model their instructions on their principles for field warfare.

The German instructions advise advances by night, and on this matter lay down numerous details to facilitate such a movement without inconvenience or commission of errors. They give great prominence to the employment of searchlights, both in large and small sizes, the latter being primarily intended for the use of the infantry in avoiding surprise by an attack from the defenders.

While the infantry is advancing, thereby forcing the enemy to show himself in order to fire and enabling our artillery to recognize its targets and keep them under observation by suitable artillery patrols sent out to the most advanced infantry lines, an artillery duel will continue.

But this duel will not be of the preponderating importance that it once

was: the besieging artillery will merely fire at the hostile artillery and attempt to paralyze it in the same manner that it fires at any other target opposing the advance of our infantry. In doing this we are but following current opinions as to field warfare, with this well defined difference, that in siege operations the proportion and size of guns will be greater than in field operations, as will also the proportion and size of the works protecting them, as well as of similar works on the side of the defenders, but the general rules will be the same. In fact, the German regulations assign to the artillery as their prime task, rendering the advance of the infantry towards the hostile position, under protection of artillery fire, as rapid as possible. And the regulations state in addition, that, in order to increase the intensity of the fire at successive points accordingly as may be required, it will be necessary to have at hand batteries of heavy field howitzers, for the infantry will move forward the more energetically, if it feels it is supported by a superior artillery fire.

It should be noted that, in order to obtain such a superiority of fire, many authors advise the concentration of fire on various targets as they successively appear, destroying them one after another by an enormous preponderance of fire. It is also desirable at this stage of the action to commence to move the medium caliber batteries forward; such a movement should be made by echelon, starting with the most mobile batteries. It may be quite useful also to construct decoy batteries in order to mislead the enemy and cause him to waste his ammunition.

The rules given in the German regulations for the advance of the infantry, are, whenever possible, similar to those prescribed for field warfare. Infantry will profit by all accidents of the situation, terrain, and weather conditions to advance from position to position.

It is evident that it is not necessary for the positions to be continuous; it will suffice if various detachments constituting the infantry line can mutually assist one another by fire action.

The distance of each advance will depend on the terrain and the nature of the defender's resistance. Light field batteries will accompany the the infantry.

The enemy should be fired at every time he appears. Great care should also be taken to locate the enemy's armored or concealed batteries, in order that every means possible may be taken to put them out of action.

From what has been set forth, it can be clearly seen that the action of siege artillery will in the future be very different from what has been customary in the past. And this brings up for consideration the question as to whether this change of method will not react upon the characteristics of the guns employed. We shall, therefore, examine the various targets now actually assigned the artillery.

First, artillery must bombard permanent modern works, of concrete or armor, and of the greatest strength. For such a task the majority of writers unite in deciding that large caliber guns, firing very heavy projectiles filled with large quantities of high explosive, will be necessary; and, in fact, in practically all armies this problem has been solved by the adoption of such guns.

Additional artillery will be required to take under fire older works, still in use in modern fortresses, and also protected points, magazines, parks, depots of matériel, etc. For such purposes many are of the opinion that

heavy field howitzers will give good results, as these guns have mobility, while now firing projectiles of sufficient size.

There remain to be considered batteries located in intervals protected by field fortifications, trenches for infantry, and mobile targets of every kind. What kind of fire is preferable against such objectives?

Let us first consider batteries of medium caliber. These used to be located behind earthworks, generally on commanding positions, and they were attacked by fire intended, first, to demolish the parapet, and, then, to dismount the guns. But now medium caliber guns will, whenever possible, be placed in pits or on slopes— not on sky lines; high parapets will be avoided, and a study will be made of every incident of the terrain with a view to taking advantage of all natural protection that can be found. The high degree of perfection of instruments for use in indirect fire, now at hand, or shortly to be provided in all batteries, permit of firing from thoroughly defiladed positions in a manner not heretofore possible. For this reason, fire for demolition against such batteries will nowadays seldom be possible: it will only be practicable to use shrapnel or shell fire against their personnel, in order to cause losses, interfere with the service of the guns, prevent the bringing up of ammunition, etc.—in other words, to paralyze, or at least diminish, the efficiency of the battery. This method of fire, with present means of observation, especially aerial, can be carried out with sufficient accuracy for the purposes indicated; but a fire for demolition can not be successfully executed under the circumstances. The need of heavy projectiles capable of demolishing thick parapets of earth is, therefore, less felt; and what we need in their place are lighter projectiles, which, weight for weight, can be fired in greater numbers and with greater rapidity. Evidently, such projectiles can also be used against the defenders' field artillery or infantry. It would therefore appear advisable to reduce the caliber of guns intended to be used for these tasks; and the number of such guns in a siege park being considerable, such a reduction in caliber would increase the mobility of artillery parks; and this would be of enormous advantage, not only in the prompt occupation of the first positions of the artillery, but also in succeeding movements, either forward towards the fortress or away from a position on which the enemy has adjusted his fire.

To sum up, then, the parks must contain two entirely different types of guns: first, guns of great power and no greater mobility than is strictly required, the number of which will depend on the number and size of permanent modern works to be attacked; and, second, guns which in caliber and mobility will approximate in type heavy field artillery.

As for the defense, since it, as a rule, will not fire at targets having a great amount of protection, the caliber of guns mounted in fortresses may also be reduced, with great advantage in rate of fire and in possible results against animate, and often mobile, targets, such as usually present themselves.

But a reduction in caliber must not be at the sacrifice of range, for in siege warfare, more than in the field, long range guns are of great utility. In the attack a long range, for reasons already given, is of great value, making it possible, as it does, to commence firing from the original, distant positions, with sufficient effect to enable the infantry to seize points necessary to complete the investment; and when that is completed, it is possible to deploy other siege batteries nearer to the lines of the defense and to one side of their direct front, in such manner as to bring an enfilading, or at least an oblique, fire on them. While for the defense long range guns are of still

greater importance, in order to hold the attacker as long as possible at a great distance, thereby delaying the period of investment and constraining the attacker to take up a longer line; or in order to sustain by artillery fire from the fortress the troops garrisoning advanced posts; or in order to sweep the terrain lying in intervals and on the flanks of the forts; or in order to fire on lines of communication or important points on such lines; or in order to fire on defiles, even when at very long ranges; etc.

In my opinion these should be the ideas to be considered in selecting a gun for fortresses and siege parks. Though, naturally, in special cases, the proportion of guns of various kinds in a siege park will depend entirely on the construction and circumstances of the fortress and its surrounding terrain, against which the guns are to be used. A proper selection in such conditions will be a most powerful factor in the success of the attack.

Another very important question is considered in the German regulations and that is: Shall we deliver the attack on the permanent works of the fortress or on the intervals?

The regulations advise the securing of the intervals first, whenever there is doubt as to our ability to secure the permanent works otherwise than by an enveloping attack; but, as a rule, the intervals and the permanent works should be attacked simultaneously.

I consider it important to consider this subject at some length.

The experience of Port Arthur, where the Japanese suffered severe losses in the capture of works which were not strongly protected, and where sanguinary fights occurred over simple material obstacles, has induced many writers to advise that the capture of permanent works be not attempted, and to suggest that the attack be directed principally against the intervals, while neutralizing the action of the forts by an intense fire from medium caliber batteries.

There is no doubt that the major part of the losses sutained in siege warfare occur during short range fighting, in which the fire from small arms, machine guns, and rapid fire guns may become annihilating when the enemy is held under their fire for but a very few moments by some simple obstacles. Wire entanglements, ditches temporarily impassable, a wall which the artillery has previously failed to destroy or at least breach, all may cause enormous losses to the attacker, who unexpectedly finds his progress stopped by such obstacles. And, considering the types of modern forts, the strong protection they obtain from the use of concrete and armor, and the obstacles by which they are surrounded, no illusion should be had as to effecting, even with a superiority of artillery fire, the destruction of such places or the annihilation of their garrisons or of their means of defense; but, while employment of powerful guns may sometimes, under favorable circumstances, paralyze the action of artillery intended for long range firing, it will be much more difficult to destroy the means for close and flank defense, if the defenders have placed these properly under cover from the hostile siege artillery. And in a well constructed fortress, it should be remembered, flank defenses are so extremely effective in the intervals that it ought to be impossible for an attacker who has succeeded in penetrating into the intervals to maintain himself there, without suffering tremendous losses. Therefore in the majority of cases, the capture of intervals will be for the purpose of enveloping the forts so as to facilitate their occupation; but such capture will not itself constitute a success enabling the occupation of the forts to be neglected.

We may add that, in general, forts will be located on points so selected as to situation that their capture will be decisive as to the fall of the fortress itself; or else will be so located as to close lines of communication that are absolutely necessary; so for these reasons also the attackers will be forced to capture the forts. This, however, should not be interpreted as excluding the case, where, the above requirements not being fulfilled, or the intervals being large, or the nature of the terrain permitting, it is possible to proceed directly to the capture of the fortress, by simply paralyzing the action of the forts and avoiding the losses which would be necessary for their actual capture.

As to the width of front to be attacked, this will depend on the nature of the fortress, its surrounding ground, and the passableness of the ground. It will evidently be necessary that any breach made in the lines of the defense shall be sufficiently large to permit of decisive action by an attacking force destined for the capture of the fortress: in some cases the capture of one fort will be sufficient for this purpose, while at Port Arthur, for example, the principal attack was directed against seven different forts, which were, however, quite close to one another. In any event, it is plain that, if sufficient front is not given to the attack, the risk is run of not having, especially at the time of the assault, sufficient space in which to deploy a superior force, thereby exposing our troops to becoming massed in a restricted zone and suffering severe losses from the front and, especially, from the flank fire of the defense.

According to German instructions, the shorter the distance between attackers and defenders, the more indispensable becomes the cooperation of the infantry with the artillery and the engineers. In general, only observers with the troops in the firing line can determine on what points the fire of the guns can be profitably increased, or when the time has arrived for lengthening the range so as to avoid hitting our own infantry.

The artillery, after having first reduced to silence the enemy's long range guns, should attempt to do the same with the enemy's guns intended for close defense, and to accomplish this purpose it will be advisable to push some batteries forward. An assault against the main works of the defense, will, as a rule, be possible only after close fighting with all modern means available; and for this reason, the greater the labor and time required to destroy defenses, remove obstacles, etc., the nearer should the final position of the infantry be to such works.

The instructions state that, in order to shorten the period of close fighting, care should be taken to make the assault from as many different points as possible, and to make full use of all advantages secured.

Habitually, the commander-in-chief decides the times and places of assaults, and, as occasion requires, issues the necessary orders for placing reserves at the disposition of the sector commandants, as well as for making secondary and false attacks.

The sector commandants regulate the fire of the artillery according to the movements of their troops.

This completes the instructions relating to the attack of a fortress—instructions which, as we have already several times noted, differ less in Germany than in any other country from regulations prescribed for field warfare. Confronted with powerful means of defense by an adversary, the Germans certainly do not renounce the methodical progress of a regular siege; but they seek to reduce as much as possible the duration of such a

period by furnishing ample offensive means, with great mobility, and by having intimate relations existing between the two principal arms, infantry and artillery, from the commander-in-chief down to the smallest organizations, including patrols.

The Defense

The same requirements as to activity, the same aggressive spirit, which characterize the German instructions for the attack of fortified places, are also found in their regulations for the defense of such places.

According to the regulations, the fortress commander is required habitually to hold himself in readiness to assist, on his own initiative, field units operating in his vicinity, and the commanders of such field troops have the right to require such assistance. The fortress commander must make such provision that, whatever the circumstances, as large a part of the garrison as possible shall be employed in external operations; and this notwithstanding the fact that the commander is personally responsible for the safety of the fortress, as long as any available means remain unexhausted. And finally, nothing must be left undone to hold before the fortress a considerable portion of the enemy's forces, and to continue resistance to the utmost extreme, in order to preserve to the country the possession of valuable territory.

Major Schroeter of the German army states that an energetic defense will not be content with repulsing assaults of the attack, but that it will, if possible, strike the first blow, with a view to paralyzing the attacker, and will not retire behind the defenses unless it has failed in its offensive movement.

The defense must never allow itself to be surprised; on the contrary, it must attempt to take the enemy by surprise. This constitutes initiative and activity in the defense of a fortress.

The German instructions state that communication with the field army must be maintained as long as possible, while contact with the enemy is to be secured from the earliest practicable moment. The fortress commander must not, therefore, passively await the enemy's approach, but must try to provoke it, which increases still more the important mission assigned to the fortresses. And the instructions call attention to the fact that the external action of the garrison is indispensable in the interest of the fortress itself, since it enables it to obtain early information as to the direction from which the attack will come, thereby making it possible to inflict severe losses as soon as the enemy arrives in front of the fortress, or attempts to deploy his artillery.

To attain such an end, it is necessary to carry on exterior offensive action by means of the general reserve, in delaying engagements and partial counter attacks by outposts, supported by the advanced positions, and with a perfectly organized system of security and information, which will permit either a commander or the artillery to profit without delay from all favorable circumstances which may arise when the attack is still unprepared to deploy a superiority of force.

The general reserve, reenforced by the fortress artillery and assisted, in certain cases, by advanced detachments, should be employed in offensive action against portions of the enemy's forces, rather than in occupying positions not supported by the fortress artillery, where it might be exposed to capture. But care must be taken that in assuming such offensive action, the retreat to the fortress is assured, and that the safety of the latter is not compromised. As may be seen, this is a difficult task to successfully accom-

plish when we consider the various factors entering into the matter, but it may lead to good results against an adversary advancing in several columns not well connected with one another.

These requirements as to offensive action and general aggressiveness, which are being more and more regarded as characteristics of the defense of fortresses, naturally influence the nature of the fortifications themselves, in order that the fortifications may lend themselves to such form of defense.*

It appears to me that the trace of the fortress should be laid out in such manner as to favor the maneuvering of the garrison; and, that the maneuvering may be to effect, it follows that the fortress should be located on the state's frontier, in order to cover the mobilization of troops in its rear, as well as to furnish a bulwark against possible raids by the enemy. Fortresses should be large assembling places for troops and matériel of every kind, and be situated along the most suitable points of the frontier; in fact, they should be true advanced bases, with power to undertake a strong offensive in directions most liable to lead to success, and to oppose hostile advance at such places as may be guarded by an inferior number of troops, thereby freeing a superior force for the field campaign.

Those large fortresses situated in the interior of a State, famous central redoubts, at one time believed to be of the greatest value, which, in addition to withdrawing from field operations immense garrisons and means of defense, occupied a large part of the interior of the national domain and cost millions, now lose all their importance. And though it may be said that these fortresses serve some purpose, in that a beaten army may take refuge in them and refit with a view to retaking the field later, yet in practice, how often has this actually happened? To negative the proposition we do not have to go for typical instances to times very remote from our own: history shows that a beaten army which is forced to take refuge in a fortress, has great difficulty in recovering sufficient energy to enable it to abandon the protection of the fortress and sally forth again to meet the enemy in open campaign.

Without considering the fact that, for an army no longer sure of victory, such fortified places inevitably control the line of retreat and paralyze movements through fear of losing this line, they hinder an army in its initiative and power of maneuver and finally become a material weakness, morally rather than physically. So it seems to me that the money required to build and garrison such fortresses and maintain them constantly in readiness to resist an enemy's attack, which every day is liable to be more powerful, had much better be spent in reenforcing the field army and strengthening it to secure a victory in the field.

A beaten army should have liberty of choice, when in home territory, as to the direction of its retreat, which should vary with circumstances; the obstruction of natural lines of advance by obstacles, properly supported by field fortifications, will permit a long and obstinate resistance, without tying the troops down and without exposing them to be shut up and besieged in a fortress. When their first line of resistance in the field is overcome, the absence of a complete circle of defense very naturally results in their falling back at once to another line of resistance. And in this manner the army remains constantly in touch with the resources of the country, which may renew and increase the strength of its army, both materially and morally.

* The Italian regulations agree in general with these views in that they require fortress commanders to assume an aggressive action with a view to containing as large a number of the enemy as possible, and certainly a larger number than the fortress garrison.—A.

That is the advantage of an open campaign, where everything is inspired with action and motion, and where nothing tends to passiveness, as do permanent works of defense which, occasionally, through the shelter they afford, lead to the loss of tired or demoralized troops.

History offers numerous examples in which the carrying out of such ideas has given better results than the sheltering of armies in general fortresses constructed before the commencement of hostilities.

As to the organization of the defense, the German instructions follow principles similar to those prescribed by them for the attack.

The defense is divided into sectors, in each of which the commander of the troops has directly under him so much of the works and artillery of the fortress as pertain to his sector. He does not, however, interfere with the chief of artillery and the chief of engineers of the entire fortress.

In consideration of the active task expected from a fortress, the best troops are assigned, not to the most exposed faces, but to the general reserve or the artillery reserve, which, as we have already seen, are intended for exterior employment.

In order to carry on operations of the kind indicated, the batteries of the artillery reserve are horsed, thus enabling them to act with the general reserve beyond the fortress, or else to move rapidly to the reenforcement of threatened sectors.

To place a fortress in a state of defense, the instructions advise the organization of battalions of military laborers, and the avoidance of the employment of civilian labor. The line troops should, if possible, be used in the preparation of only their own fighting positions; and for such positions their own officers are responsible for the proper execution of the work, even though engineer officers be sent to assist or advise.

The main position of the defense is generally established along the most advanced line of permanent works; and as regards the construction of these works, it appears to me to be useful to examine the rather important question of the separation of the lines for distant or long range defense and for close or short range defense.

The task assigned to permanent works is complex. Primarily, they are intended to protect the fortress from being taken by surprise, and they should, even in times of peace, be capable of performing this duty. Then they serve to protect, in the best possible manner, a certain number of powerful guns, main factors for long range defense. Lastly, they form by themselves on the principal line of defense the points of resistance which are the most formidable and the most difficult to capture, and from which the defender can contend most efficiently and for the greatest possible length of time against the final assault of the enemy for the capture of the fortress.

For this last important task there are required special provisions, which are intended to be brought into use only at the last moment, and which should, therefore, remain intact as long as possible, because of their great importance for close range defense; in fact, as we have already had occasion to note, they should inflict on the attacker severe losses, either destroying him or rendering his attack so bloody as to destroy his advance. Therefore in my opinion, it is important to place these special means in the permanent works, separated and away from long range guns, in order to protect them from the enemy's long range guns, which will seek, from the beginning of the action, with all means in their power, to damage the permanent works of the

defense, in order to destroy their usefullness, and open up a way for their own infantry.

Another question on which the German instructions differ from those of other nations (as for example the French), is that of advanced positions, to which great importance is attached.

The regulations do not advise *exterior* positions, that is positions beyond the protection of the fortress artillery, but state that advanced positions are useful when they can receive energetic support from the main position. According to the German regulations, advanced positions are intended, either to extend the radius of action of the fortress and thereby maintain, with greater security, connection with the field army; or to cover a weak front in their rear; or else simply to delay the enemy's advance on the main position.

In deciding upon defending advanced positions, special attention must be given to the terrain, with a view to determining the amount of resistance which it will afford to a defensive organization, the field of fire, and the support that may be received from the main position or the reserves. These same considerations will enter into the determination of the size of garrison assigned to such positions, as well as of the time for which the position should be held.

The instructions state that advanced positions are, in general, organized on the same principles as the main position; a retreat should be assured, and, as in some cases heavy artillery may be employed, measures should be taken in advance for withdrawing it at the proper time.

Advanced positions are under the orders of sector commandants, and are occupied by the regular sector troops.

The German instructions, as we see, attach great importance to advanced positions; while, on the other hand, they do not favor positions in rear of the main line, or so-called supporting positions; such, for example, as are extensively treated of in the French regulations, which state that the organization of supporting positions in rear should be undertaken from the very beginning of the attack, and be extended gradually as the attack progresses, until the movement shall be complete at the time when the security of the principal zone of defense becomes menaced. The German instructions affirm, quite to the contrary, that, in the face of a superiority of fire, it is, as a rule, advisable for the artillery of the defense to maintain its position till the last round, rather than to attempt to retire to a new position further to the rear. They add, however, that darkness or a pause in the firing might enable a movement to the rear to be carried out. But in no case should forces be withdrawn from the main line or from the reserves to reinforce a retreat, as long as any possible hope remains of repulsing the enemy's attack.*

Which is the preferable method to follow?

While it appears to me that, for war, no absolute rule can be prescribed, varying conditions advising the giving of greater importance to a second line of defense in rear of the main position, or the establishing in front of the main position of a series of advanced positions; yet, as a rule, the German tendencies appear preferable. While there is a very substantial difference between the two methods, yet they are alike in that both require two successive positions of defense, instead of but one.

* The Italian regulations also state that as a rule troops shall not be withdrawn from the main or exterior works, to support successive advanced positions gradually closing in to the fortress; but such positions shall be improvised, when necessary, wherever favorable points of the terrain occur.—A.

The choice of position for the main line of defense of a fortress is determined by the nature of the terrain, by the length of line the strength of the garrison will allow of manning, by the special mission of the garrison in the theatre of operations, by the lines of communication which are to be protected, etc. According to these considerations, the permanent works are constructed. But it is evident that, as far as possible, it will be advisable at the time of attack to dispute the possession of exterior ground as tenaciously and for as long a period of time as practicable, with a view to compelling the enemy to deploy and bring his artillery into action at long range, and to disclose his forces and intentions—in every way delaying his advance towards the fortress. And while exterior positions may tend to accomplish these objects, yet, being far from the fortress and beyond the support of the fortress artillery, they are liable to lead to a dispersion of forces and seriously expose the troops to losses of men and matériel. On the other hand, advanced positions, being under effective protection of the artillery of the main line, have their retreat assured and neither their garrisons nor their artillery (which should be mobile) are lost for the principal defense.

Advanced positions have the well defined mission, thoroughly understood by the garrison, of simply delaying the enemy's advance; so their abandonment, being foreseen, will not produce any demoralization. The abandonment, however, should not occur under pressure from a victorious and pursuing enemy, but should, on the contrary, be effected opportunely, under the protection of a heavy and well-controlled fire.

The opponents of advanced positions state that they are exposed to the fire of a superior number of guns without being able to make an adequate reply. But in laying out these positions, such defects should be kept in mind and avoided in the best way possible. Finally, they should be occupied at the beginning of the siege, at a time when the enemy's heaviest artillery is not yet in position. When they are attacked by such artillery they may be evacuated, as the object of their existence, in causing the enemy to deploy at a greater distance from the fortress, will have been accomplished. In this manner, advanced positions enlarge the radius of action of the fortress, without the inconvenience of establishing too long a line of defense in proportion to the means of the garrison.

Without entering into an artillery duel, long range mobile artillery can, from advanced positions, make quite a marked impression on the enemy, even from great distances, by interrupting the deployment of his artillery or the construction of his depots and magazines; by interfering with the placing of reserves in rear of crests defiladed from the main position; by preventing the occupation of positions suitable for batteries or for observation stations; by firing on important points; etc., etc. When practicable, deceiving the enemy with decoy batteries may also be useful.

The principal part of the forces of the defender should be in the main position, which should be held at all costs, and at the expense of the best matériel and moral energy; and, it may be remarked, a position in rear of the main line fatally absorbs a part of such energy, without any hope that it may become an efficient factor in prolonging the defenses, as a retreat from the main position, at a time when the attack enters it, is a case quite different from a retreat from an advanced position, as previously described.

The main position should be selected and organized in such manner as to obtain the greatest defensive power and the maximum effect from its fire action. What cannot be accomplished from such a position, can, as a

rule, hardly be hoped for from some other position less favorable to a tenacious defense.

Therefore, for both material and moral reasons, I consider it advisable to commence action against the attacker from advanced positions, and to fight the assault to a finish on the main position.

Only in special cases, where the terrain or the construction of the fortress permit it, will it be expedient to establish in advance a position in rear of the main one.

According to the German instructions, the main position is outlined by permanent works and armored groups, which serve as points of support for troops operating in the intervals between them.

Positions for infantry and artillery should be selected with a view to the special characteristics of the respective arms, and with a view to assuring cooperation between them. The infantry should be sufficiently in front of the artillery to enable it to avoid losses from fire directed against the latter.

The artillery furthest to the front should everywhere attempt to keep the line of investment as far away as possible, in cooperation with the infantry repulsing all attacks.

Only light or field batteries are, as a rule, placed in position near the infantry, and the latter should be disposed in groups, so situated as to afford mutual support to one another.

It is to be remarked that all these regulations deal primarily with engagements with the attacker's mobile troops.

In establishing lines of communication the regulations advise invariable decentralization by sectors, the fortress commander being connected with the sector commandants and the latter with their own units. There is, for example, no direct communication between the fortress commander and the sector chiefs of artillery.

During the investment, the outpost service is conducted in the same manner as in field warfare. Later, as the attacker closes in, the outpost line gradually changes into a first line of resistance. Assisted by the artillery, it presents a constantly increasing opposition, in order to keep the enemy's advanced lines as far distant as possible and to protect the advanced observing stations of its own artillery; when necessary to retire, the ground lost should be disputed yard by yard, and every favorable opportunity taken advantage of for making counter attacks.

The fortress artillery, during this period, has a most active rôle: whenever its fire would probably give results, there should be no thought of saving ammunition, but fire should be immediately opened on all targets that may appear. Advantage should be taken of the maximum range of the guns to fire on depots, parks, defiles, etc., and especially on observers, reconnaissance parties, aerial targets, and hostile batteries firing on any balloons of the fortress.

The artillery will often have advantageous targets when the hostile infantry is taking up its position for investment, for at that time the infantry may be in a precarious condition, poorly sheltered and insufficiently supported by its own siege artillery. Here the action of artillery posted in advanced positions may become most important in forcing the enemy to establish his line at a considerable distance from the fortress.

When the direction of the attack has been ascertained and while the artillery of the attack is being deployed, the artillery of the defense, reen-

forced by the reserve from the foot artillery and by other available batteries from the least threatened sectors, should let nothing prevent its firing first upon the enemy.

This is the most favorable moment for undertaking either volley firing or offensive action, as the attacker will not yet be completely ready to act with all means at his disposal; therefore the artillery should fire, whether it be day or night, at every proper opportunity, and without regard for saving of ammunition, against any hostile batteries that can be seen, or at least that are located within reasonable limits. This is the most important time for acquiring a decisive superiority over the attacker, who is deploying over a terrain which is well known to the defense, and over which fire should have been previously carefully plotted.

Offensive action (by general or local sallies) is undertaken by the general or local reserves; they should be carefully prepared in advance, with a view to securing a surprise, and should as a rule be made by night and supported by artillery and searchlights.*

Finally, opportunites for surprising the attacker will become rarer and rarer, as the line of investment becomes more effective and more complete.

When the artillery of the attack opens fire, all the batteries of the defense, without regard to their former objectives, will fire upon those targets upon which it appears the quickest results can be obtained. This rule is general, although it does not appear in the instructions of many other armies.

A certain number of large caliber batteries will, notwithstanding the artillery duel, continue to fire against the attacking infantry, which, after their siege artillery has opened fire, will sooner or later advance.

A part of the gun batteries, together with the field artillery, will remain constantly ready to oppose any movement of the enemy.

It should be noted that in all these rules, opposition to the mobile troops of the attacker, rather than against his batteries, is the prime consideration. The instructions also state that, when the defense has succeeded by its artillery fire and opportune counter attacks in holding the hostile infantry with their artillery observing stations at a distance, it will be possible, although the attacker may have a superiority of forces, to hold a considerable part of the artillery of the defense in readiness for action.

As the infantry of the attack gradually advances, all batteries still able to go into action should preferably direct their fire on this infantry.

Armored batteries have a mission of capital importance: until they are silenced, an enemy will have small probability of definitely establishing himself in their front.

According to the German instructions, resistance along the main line of defense should continue to the extreme limit. An objection may be raised that mobile batteries about to be overwhelmed should retire to a position in rear of the main line; but, in my opinion, they would be of but little use there, for in a majority of cases they would be exposed to such serious losses while in the act of retiring as to compromise their ability to resume the action. Consequently, before they could reopen fire, a considerable length of time would elapse, enabling an adversary to overcome the main line of defense, which would be the weaker by reason of the retirement of these batteries. But I believe the worst consequences of a retreat is the moral effect produced on the defense; as the infantry, seeing powerful guns, which should be an

* The Germans attach great importance to the employment of searchlights.—A.

effective barrier against the enemy's advance, retiring, inevitably lose heart and are themselves induced to retreat.

Furthermore, it is precisely during a retreat that a bold and daring enemy can inflict the greatest losses (for retiring troops are unsheltered), and a decisive blow may well be delivered at such a time. While, therefore, special situations will arise, in which it will be advisable to act otherwise, yet I believe that, as a rule, from any point of view, the idea should everywhere be dominant that on the main line of defense resistance should be made to the uttermost extreme, and with all available means. Rather than to retire to a supporting position, everything should be brought up into line from other parts of the fortress, to stem the advance of the attacker and to attempt, during his inevitable disorder, to drive him back by counter attacks—especially on his flanks, with the assistance of fire from flank works. In fact, the German instructions state, that when an assault is foreseen, all available forces should be assembled on the main line—even the reserves, notwithstanding possible exposure to losses. And it is added that, as the assault progresses, all available batteries on fronts not the object of attack should be brought up to covered positions to the rear and to the flanks, in order to participate in the close range action of the contending forces. Batteries in adjacent sectors also should be so disposed as to help in resisting the attack.

The French regulations are quite different; they state: "When the hostile artillery has obtained a superiority, it is evident that a continuation of the duel will only increase losses; so, commencing with those most exposed, the guns will be gradually retired to positions in support."

With regard to the infantry, the German instructions state that it should attempt to destroy the enemy's works of approach, in which it should be assisted by engineers and artillery, and particularly by the means provided for flank defense.

The French instructions, on the other hand, state that when the attacker has succeeded in entering the main line of defense, the mobile troops will retire to the supporting positions, where they will be assisted by either the artillery or the reserves.

We see that there is a notable difference between the two instructions: the Germans reenforce the main position with everything available; the French advise (although with many reservations) the abandonment of the position when the attack has obtained a decisive superiority.

In conclusion, it may be said that the German ideas on siege warfare differ in spirit from those of other armies, in that they require great activity and aggressiveness, and have a tendency to follow, wherever possible, the rules prescribed for field warfare.

These tendencies, as we pointed out at the beginning of this article, are the result of the special study made in Germany in the subject of fortifications and the art of sieges. And, likening the offensive maneuvers of siege warfare to those employed in the field, where it is the object to strike a decisive blow, in a direction determined by the strategical situation, the art of siege warfare requires a prompt decision as to the direction of the attack against the fortress and energetic execution thereof; while, in defensive siege warfare, the German regulations emphasize the requirement that the fortress maintain as active a rôle as possible, in order that its garrison be not lost as a factor in the field campaign, in which only can decisive results be obtained.

—*Rivista d'Artiglieria e Genio.*

THE DEVELOPMENT OF OUR NAVY'S SMOKELESS POWDER

By LIEUT. COMMANDER RALPH EARLE, U. S. NAVY

The Proceedings of the Naval Institute contain the very best and most valuable professional works on all subjects, and the writer in submitting this plain story of our smokeless powder hopes that it may find a place in our service publication. That it may interest many officers and place on record before the service the development of our present powder before the progress and the men responsible for it are forgotten is the *raison d' etre* of this article. The names of many of the men connected with this development are not generally known to the service but the navy is justly proud of their work and should give due credit to them by acknowledging and placing their achievements in our Proceedings. The building by the navy of one of the finest powder plants in the world without a single accident to its employees or product is surely a feat for the navy to be proud of. Compare our results with those obtained in France and we see how high we stand, for there M. Vielle, the French chemist and the inventor of nitrocellulose powder, probably the greatest explosive chemist in the world, although in charge of the government plants, has yet seen two fearful disasters take place in his navy, both of which were due to improperly manufactured powder.

Most of us do not know the men who have placed our navy in its powder manufacture on such a high plane. We do know that the French disasters occurred because their government factories were controlled entirely politically, so much so that not even an officer's inspection of the manufacture was allowed, and yet no one who has been acquainted with their service and their naval officers can have the slightest doubt that, if the same opportunity had been afforded them, the results would have equalled ours.

The adverse criticisms of our powder that appear frequently in various publications have never yet been based on fact or expert knowledge, there has always been some ulterior motive in them or some axe to grind. The record of our powder speaks for itself and whatever may be said of it by foreign critics—one can hardly call them disinterested either—it is *not* and never has been similar to Poudre B* of the French with which it is continually and very erroneously being compared to its detriment.† We do not claim the powder was as good at the start as it is now, for improvements in the manufacturing methods and chemical structure of it are continuing daily.

If we exclude Greek fire, which by an addition of saltpeter was made explosive at a very early and uncertain date, there existed from the 14th century to the 18th century but one explosive, black powder.‡ M. Berthollet, a French chemist, toward the end of the 18th century made the first steps towards a new explosive when he prepared potassium chlorate and endeavored to apply its extraordinary oxidizing property in the manufacture of explosives; but his researches yielded no results and ended on account of severe explosions.|| Next came investigations upon the actions of concentrated nitric acid on starch, wood, cotton, and other organic compounds;

* See *U. S. Naval Institute Proceedings*, Vol. 37, No. 140, p. 1281, for detailed comparison of powders.

† See *U. S. Naval Institute Proceedings*, Vol. 38, No. 141, p. 132, for a detailed answer to the most common criticisms.

‡ Black powder is extensively used in certain types of blasting work and has a large sale for sporting powders, it being much cheaper than smokeless. Its accepted composition to-day is 74 per cent saltpeter, 15.6 per cent charcoal, 10.3 per cent sulphur; the moisture in the powder after drying generally remains at least .6 per cent.

|| For much of the data in this article I am indebted to a lecture given by Prof. W. Will some years ago.

the most prominent men in this field—which, however, bore no real results—were Braconnet, Pelouse and Dumas.

Detonators and percussion caps were developed through the discovery of mercury fulminate by Howard in the year 1799. This substance has the chemical formula $Hg(CNO)_2$ and is prepared by a solution of mercury in nitric acid being treated with alcohol. The manufacture of fulminates was taken up by Liebig and Gay Lussac, and the compound was used as early as 1815 by an English gun maker, Joseph Egg, as caps for small firearms.

Between 1840 and 1850 occurred the investigation that revolutionized the explosive industry, and resulted in the discovery of nitrocellulose by Christian Friederich Schönbein, and the preparation of nitroglycerin by Ascanio Sobrero at Turin.

C. F. Schönbein, in Basel, discovered in 1846 in his experiments on the oxidizing effect of sulphuric and nitric acid, the fact that, when cotton is dipped in such a mixture, a remarkable reaction takes place, wherein the outer appearance of the cotton has not been at all changed. It shows the same appearance, the same structure as before dipping in the acid mixture, but its chemical properities are entirely changed. The substance previously so tame, has suddenly become an eminently explosive compound.

Prof. R. Bottcher, who had also discovered an explosive cotton while engaged in similar experiments at Frankfort am Main, joined with Schönbein on October 5, 1846, and published the process for the preparation of guncotton. In other words Schönbein is the discoverer of nitrocellulose. Soon guncotton was tested in England at Woolwich Arsenal, under the influence of F. Abel, and its manufacture on a large scale was undertaken by the firm of John Hall & Sons at Faversham; and scientific experiments took place by a special commission of the German confederation to which, among others, the Austrian lieutenant, von Lenk, belonged, and which was assisted by Liebig as scientific expert. Large rewards were promised in case guncotton should show itself a substitute for black powder.

The English investigations ended suddenly in 1847 in consequence of the explosion of the still unfinished factory at Faversham. In 1848 there also occurred in France big explosions at Le Bouchet and Vincennes, terrible reminders that one must not underestimate the dangers which were involved in the manufacture of the new explosive.

The Austrian government bought the process from the discoverers and continued experiments in Vienna Neustadt under von Lenk. He improved the manufacture in many respects. He boiled the cotton, previously spun into yarn for more ease in handling, with potash solution for complete removal of the fat, he introduced a very thorough washing of the nitrated product in running water lasting several weeks, then treated it with a warm soap solution, and finally moistened it with water glass (sodium silicate) solution. This was to increase its stability through the alkali carbonate formed by contact with the air, and to give a denser, more slowly burning nitrocellulose through an inclusion of incombustible silica in the pores.

Lenk's cotton enjoyed a reputation for some time of being a sufficiently stable product, so that in the beginning of the '60's nothing appeared to hinder a general application of guncotton. But the overcoming of the other difficulties, especially in its ballistic application, proved greater than had formerly been supposed. The guncotton burned so rapidly in the barrels that the weapons were damaged or burst.

In spite of many a preliminary treatment by spinning the nitrated

fibers into strings and cords, the combustion could not be controlled in the necessary way. So, when in 1862 the explosion of a guncotton magazine in Siemering Heath occurred, and in 1865 the explosion of a second magazine on the Steinfelder Heath, near Vienna Neustadt, both of which were ascribed to a spontaneous ignition of the guncotton, the manufacture of guncotton came to an end also in Austria.

But, in the meantime in England, under Frederic Abel's supervision, experiments were carried on diligently. Abel came to the conclusion that the objections which had led to giving up the work on the continent were exaggerated and that the unfavorable judgment in regard to the stability of Lenk's cotton was not justified. He carried out similar experiments to Lenk's and found that such purified guncotton answered all necessary demands in regard to stability. He improved methods for controlling the velocity of the explosion by pulping the nitrocellulose thoroughly in a pulping machine and then compressing it under great pressure.

This pulping process formed the key to the solution of the manufacture of stable guncotton, and *thus modern guncotton really dates from the year 1865.* Abel also introduced the granulation of the pasty mass with a small amount of binding substance in a vessel with swinging motion, and in 1865 he protected by patents the use of a mixture of soluble and insoluble nitrocellulose with the addition of solvents such as ether alcohol as a binding agent for the preparation of solid, that is, gelatinized, masses. It is unknown whether he carried out the process at this time.

In order to use this new explosive it was necessary to develop primers and fuses to ignite it and thus obtain the benefit of its properties. Their development came about indirectly through the discovery of nitroglycerin by A. Sobrero, of Turin, in the year 1846. This substance is the product of the action of nitric and sulphuric acids on glycerin.* Immediately on the discovery of this compound he noted the terrible explosive effects on striking or heating it.

Nitroglycerin had been known for 20 years without other than a medicinal application until about 1860, when A. Nobel, of Stockholm, began his experiments in applying its energy for explosive purposes. He was engaged in developing a good blasting material. In 1864 he had tried to increase the effect of the simple fuse by a slight addition, that of an initial charge of quickly burning black powder. He finally, in 1867, found the solution by using mercury fulminate igniting caps for detonating nitroglycerin. He was the first one to show that this substance can detonate other substances.

It was this discovery of Nobel's which released for use in blasting, and other explosive uses, a whole series of explosive compounds.

It is said that A. Nobel by accident hit upon the mixture known as dynamite. He was shipping nitroglycerin in sheet iron canisters, which, to be protected from shock or blow, were packed in a bed of kieselguhr. One of these packages leaked and the nitroglycerin oozed out into the kieselguhr. This attracted Nobel's attention to the remarkable absorptive power of this earth. He found that with a content of about 75 per cent nitroglycerin a plastic mass is obtained which is much less sensitive to shock or blow than nitroglycerin, and in consequence of its plastic nature is exactly fitted to the manufacture of cartridges, which can be easily fitted into drill holes. The manufacture of nitroglycerin then grew up enormously. In 1861 it was first

* See Explosives, Brunswig, by Munroe and Kibler

manufactured by Nobel on a commercial basis in the vicinity of Stockholm. In 1865 A. Nobel started the famous nitroglycerin factory at Krummel on the Elbe, which is still the largest factory on the continent.

Edwin O. Brown, a co-worker with Abel, and second chemist of the English war ministry, showed soon after that Abel's guncotton products could be brought to detonation in the same way.

Besides dynamite, guncotton here came into extensive use, after Brown had shown that it would give a complete detonation even in a wet condition with an initial charge of dry guncotton.

In 1866 the manufacture of nitroglycerin was prohibited by Belgium, Sweden, Denmark and England; but this prohibition was quickly repealed as the safety of dynamite began to be proved.

To show the rapidity with which dynamite became common it is instructive to state that its manufacture in 1867 was but 11 tons, while in 1874 it was 3000 tons, and that now 2,000,000 tons are made yearly.

To develop a powder for ballistic purposes was the next problem. In 1860 the English captain, Noble, introduced the crusher gauge for the measurement of powder pressure. The first actual successful steps towards the development of a smokeless powder according to modern ideas were first, the invention of the E. C. powder by Reid and Johnson in 1882, and next, that of the J. B. powder by Judson and Borland. The present smokeless powder industry, however, only dates from the manufacture of the poudre B by P. Vielle in 1886, and of ballistite by F. Nobel in 1888. Vielle discovered in the gelatinization of nitrocellulose a method for the satisfactory regulation of its velocity of combustion. The English cordite is a modification of Nobel's ballistite. Vielle's powder is a single base powder of nitrocellulose, while ballistite has the two bases, nitroglycerin and guncotton.

The foregoing notes have served to trace the events in the discovery and development of a smokeless propellant, the advantages of which from a military standpoint are so great that the problem of finding a stable progressive smokeless powder for the use of our navy became urgent, and our Navy Department therefore undertook its solution. Our guncotton factory at the Torpedo Station in Newport had been set in operation in March, 1884. The smokeless powder plant there was really started from saucepans and mortars used in researches in the laboratory of Prof. Charles E. Munroe, who had joined the Torpedo Station in 1886. Actual powder manufacture, the outgrowth of these experiments, seems to have been formally established by B. F. Tracy, Secretary of the Navy, in 1890, when manufacture of indurite was first begun, and the guncotton and powder manufacture were consolidated under one head. At this date we find on duty there the following prominent chemists who are primarily responsible for the successful results obtained in our navy with smokeless powder: Prof. C. E. Munroe, then in charge with G. W. Patterson as his senior assistant; also Mr. Tobin, who later became the head chemist of the station. When Professor Munroe left the station in 1892 H. F. Brown was appointed as his successor.

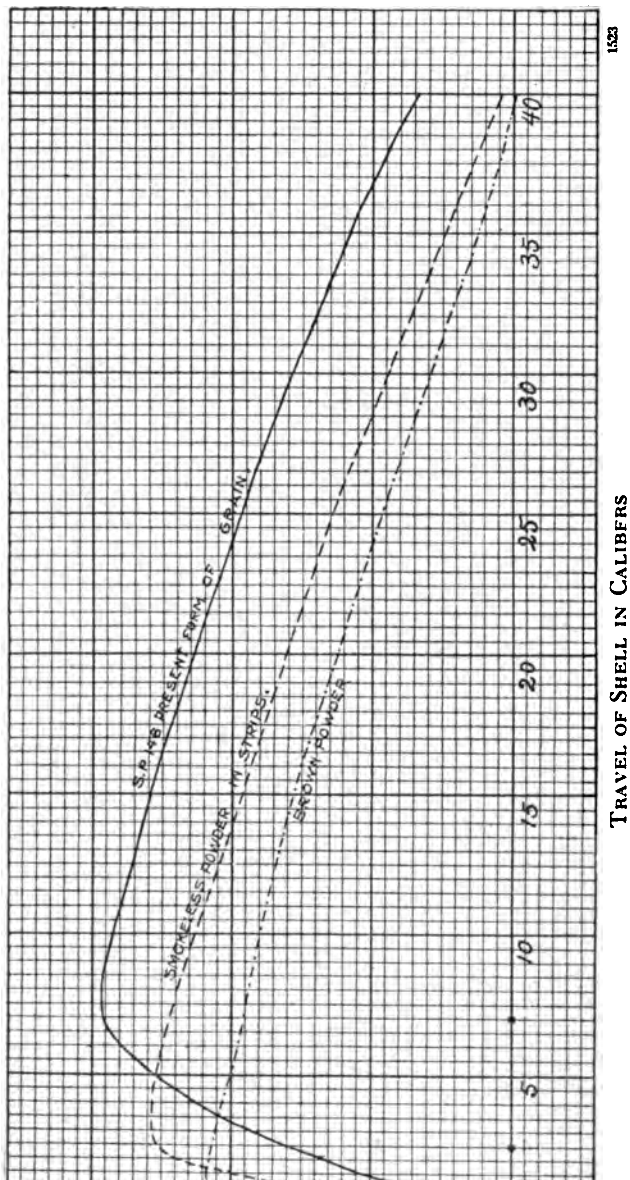
The result of Munroe's experiments was the propellant known as indurite manufactured in 1891, which was a single base powder, the first example of such in the art, made from a specially purified high nitration guncotton colloided with mono-nitrobenzene, which substance is known commercially as oil of mirbane. By indurating this plastic mass the colloiding agent was removed. Samples of this indurite made in 1891 are perfectly stable to-day.

A process and the necessary machinery were then developed for producing indurite, which was used experimentally in guns up to and including our 6-inch. This substance was not experimented with after Prof. Munroe's departure from Newport, due to several cases of instability in samples which led his successors into other lines of research. Upon Prof. Munroe's detachment a naval officer was placed in direct charge of the factory.

A single base powder of guncotton, barium and potassium nitrates, and acetone, was next produced, but this was, on account of its brittleness, superseded by a product corresponding to the French powder that was then being manufactured for sale, and is similar to that used in their navy at present, in that it contains two types of nitrocellulose. This contained soluble and insoluble nitrocellulose, barium and potassium nitrates, and was colloided at first with acetone but afterwards with ether alcohol. Patents were taken out on this powder in 1895 by Commander G. A. Converse, U. S. N., and Lieutenant J. B. Bernadou, U. S. N., who were both then on duty at the Torpedo Station, the latter officer being an excellent Russian scholar and the translator of a valuable work by Mendeléef on powder. In the summer of 1895 Lieutenant Bernadou gave to Mr. Patterson a small sample of powder which he had obtained from Russia and which represented the type of powder in use there at that time. The analysis by Patterson showed the powder to be composed solely of a soluble nitrocellulose—quite different, it is to be noted, from the mixture of the two grades of the nitrocellulose then and still used in the French powder—colloided with ether alcohol. Its nitration was found to be about 12.45 per cent. Experiments commenced in November, 1895, resulted in the discovery early in 1896 by Patterson of the mixture of acids necessary to produce the desired result. This year, 1896, then is the date of the adoption of our present powder. The composition of the powder is based on the results of the work by the Russian chemist, Mendeléef, who deduced a theoretical per cent of nitration for the nitrocellulose required to obtain the greatest gas volume under ballistic conditions, calling it 12.44. The chemical formula given for it is this ($C_{30}H_{38}(NO_2)_{12}O_{25}$) which upon being exploded in a gun breaks down into ($30CO + 19H_2O + 12N$).

Practically there have been found the following differences in velocity due to the various percentages of nitration: in a 7″/45 gun it requires 65.8 pounds of powder of 12.29 per cent nitration to give the same velocity as 60 pounds having a nitration of 12.77 per cent; in a 6″/40 gun 25.8 pounds of powder at 12.57 per cent nitration equalled 23.6 pounds at 12.80 per cent; and 343 pounds of nitration of 12.35 per cent in 12″/40 gun give the same velocity as 314 pounds of 12.65 per cent nitration.

At this point it might be well also to answer a question frequently heard in the service as to just what the gases of an explosion contain. A complex series of gases is to be found due to the volatiles and rate of burning in a gun. Quick powders, *i.e.*, those that are entirely consumed before the projectile leaves the gun, give a faint white smoke and high chamber pressures; while slow powders, *i.e.*, those that are not burned by the time the projectile leaves the gun, usually give orange colored smoke, pungent odors and low chamber pressures. The higher the pressure the more nearly the conditions of the theoretical equation of Mendeléef's are reached. At full muzzle velocities we now find carbon dioxide, carbon monoxide, nitrogen, hydrogen, steam, marsh gas, and traces of ammonia and cyanogen compounds.



Pressure curve of powders in a gun. Data determined at Indian Head in the fall of 1901. Gun in use was a 6″/40.

The maintenance of gas pressure in the bore of guns is shown in the diagram herewith that has been made from actual results obtained in firing black, brown, and smokeless powders, and which gives graphically the reason that we use smokeless powder and are enabled to reach the modern high velocities.

The present form of powder grain was not the first type tried by any means and much experimentation has taken place for years along the line of developing the most suitable granulation for powder. Amongst other forms a grain with 18 perforations was once in use. The present multi-perforated smokeless powder grain, a cylinder with seven longitudinal holes, was designed by Maxim and Schupphaus, and the patent was sold by them to the Du Pont Company, who gave it to the navy.

Lieutenant Bernadou, with the head chemist at Newport, H. F. Brown, after the proper mixture of acids had been determined in the laboratory by Patterson, developed a method for the manufacture of this powder on a large scale based on the laboratory results, which method showed the practicability of duplicating the Russian type of powder. That is the smokeless powder now in use not only in our navy but also in our army.

In 1895 there were three private explosive plants all operating independently in which the manufacture of such a powder was feasible. These plants were the Laflin & Rand Works at Haskell, New Jersey; the Du Pont Works at Carney's Point, New Jersey; and one concern on the west coast known as the California Powder Works, which manufactured its nitrocellulose at Pinole, and the remaining portion of its powder at Santa Cruz, the nitrocellulose from Pinole being shipped there. These companies differed widely in their machinery and methods but all undertook the contracts for powder, the specifications for which were based on the above mentioned Newport laboratory work.

The first powder delivered by a private firm was proved in June, 1897, and was made at the Carney's Point plant, the powder being designated as S. P. 3. The California Powder Works in July, 1898, had its first product known as S. P. 7 proven, and similarly the Haskell plant had its first proven in May, 1899, known as S. P. 34.

The Bureau of Ordnance decided in September, 1897, to build a powder plant, and under date of September 28, Lieutenant Commander T. C. McLean, U. S. N., inspector in charge of the Torpedo Station, appointed a board consisting of Lieutenant Kossuth Niles, U. S. N., H. F. Brown, Karl Hedberg, and Frederick Kniffen, to prepare plans and specifications for a factory having a capacity of 1000 pounds per day. These plans were submitted on March 31, 1898, and specifications were given on April 20, 1898. In July, 1898, Congress made available the funds for the erection of a navy factory to be located at Indian Head, Maryland, this point being about 20 miles below Washington on the Potomac River and Mattawoman Creek, it then being the site of our ordnance proving ground.

Shortly thereafter Lieutenant Bernadou was ordered to the Bureau to revise these plans and start the work at Indian Head. Patterson was chosen chief chemist at the Indian Head plant in July, 1899, by a board consisting of Captain Couden, Lieutenant Bernadou and Brown. In the face of great obstacles Captain A. R. Couden and Mr. G. W. Patterson started the work at Indian Head and evolved the present splendid powder-making plant. The first completed powder grain was run out on June 28, 1900, Lieutenant Joseph Strauss being then in charge of the factory. It was a gnarled and

spotted grain, a great contrast to the beautiful clear, translucent grains of the present day, but still it marked the fact that at last we possessed a working powder factory. The first completed index of powder made at Indian Head was known as S. P. 148 and this was proved in February, 1901.

A fourth private plant was built at about this same time (1900) at Parlin, New Jersey, and it was known as the International Smokeless Powder and Chemical Company. This company obtained its supervising force from men at the Torpedo Station, where they had been trained in the investigations, developments and machinery necessary to produce powder. The company obtained contracts from the Navy Department by underbidding the other three private firms by one cent per pound. The first index of powder delivered by them was known as S. P. 199 and was proved in April, 1902. Its success in a great measure was due to the energy and skill of Mr. C. F. Burnside, who is now with the Du Pont Company.

It is thus seen that four firms started in to manufacture cannon powder shortly after the beginning was made by our own government plant at Newport, which plant had delivered the navy's first index of smokeless powder in season to be proved in March, 1896. The Navy Department gradually transferred its powder manufacture to the Indian Head plant and none is now made at Newport.

This powder developed by Patterson from the sample given him by Lieutenant Bernadou, and made commercially practicable by H. F. Brown and the two men just mentioned, was continually improved upon by them and by the personnel of the private plants, which had reached corresponding results and details of manufacture independently after being asked to undertake the work.

The success and cheapening of the manufactured product is traceable in a large degree to a few individuals and the ones most prominent in contributing to the results deserve to be known in the service. It must be borne in mind that the private firms have contributed in a very large degree to the development of powder in this country and more particularly so after their consolidation under one technical head. H. F. Brown, who had some years before left the Newport plant to develop the Parlin plant, was given this technical direction of the four companies mentioned previously in the year 1904.

The dehydration process by which the water remaining in the nitrocellulose after its washings is displaced by alcohol and the excess alcohol then squeezed out in a hydraulic press—one of the basic operations in manufacture—was brought about by Francis G. Du Pont and applied by him at Carney's Point in 1897. The combination of these two processes into the one receptacle was worked out by W. C. Peyton at the California Powder Works. These two men appear to deserve also equal credit for the solvent recovery process by which during the drying of the finished powder a large proportion of the ether and alcohol used in colloiding it is reclaimed, purified and used again in manufacture, as they really developed the same operation independently of one another though practically at the same time. Francis I. Du Pont, at Carney's Point, produced the Du Pont nitrometer for the nitrogen determinations, which instrument has been a great laboratory help. At the California plant Robert Robertson was the great factor in progressive development and improvement, as was H. C. Aspinwall similarly at the Haskell powder plant.

The Indian Head plant is still under the skilful direction of G. W.

Patterson, its first head chemist, who has proven to be not only a chemist but a mechanical engineer of much ability. The design of its dehydration, macaroni and finishing presses can be attributed more to W. C. Peyton than to any other one person. The success of our government plant in great measure is directly traceable also to Rear Admiral Joseph Strauss, who from the start initiated and forced to completion valuable and essential improvements and has always stood as its sponsor in all its progressive development. The present sulphuric acid plant which practically makes the navy independent of privately controlled sources of supply is but one of his achievements there. This sulphuric acid plant succeeded in making acid at about \$.0065 per pound or about 65 per cent of the market price when that plant was built. The mixed acid made costs \$0.032 per pound as against \$0.035. The only supplies now purchased by our navy factory are the Tennessee fiber cotton, the sodium nitrate (Na NO3) from the Atacama and Tarapaca provinces of Chili, where it is found in layers one to five yards deep, the alcohol, and the sulphur. To manufacture a pound of powder now requires approximately .67 pound of cotton, 3.14 pounds of mixed acid, and .75 pound of alcohol. The soda nitrate is used for the manufacture of nitric acid and the sulphur for the sulphuric acid.

Most radical improvements in the various steps required in the manufacture of smokeless powder both as regards the materials and the machinery used are constantly occurring. For the cellulose several materials have been experimented with, these being cotton waste, cotton rags, long and short fiber cottons. The purification and preparation of these various types have been ever to the one end of getting a better product finally. At the present time a specially grown, treated, and purified Tennessee short fiber cotton forms the cellulose. The ether, the alcohol, the soda nitrate, and the acids are the very best that science can produce, as is likewise the water, of which 75 gallons are used for every pound of finished powder.

The Du Pont Company has just invented a new improved method of nitrating cotton and their plants have a capacity of 35,000 pounds per day of nitrocellulose. This process is now to be installed at our Indian Head plant, the plans therefor having been furnished by the Du Ponts.

For many years our powder was an absolutely pure nitrocellulose colloid but the necessity of having the many people under whose care it was placed from time to time familiar with its stability led to an endeavor to put stability indicators into powders. Rosaniline, which colored the powder a brilliant red, was introduced at Indian Head by Patterson in 1902, incorporated in 1907, and was a success there, but was abandoned because the different plants manufacturing powder for the navy did not turn out a product uniform in color, due partly to their water and partly to their storage of the rosaniline in copper instead of galvanized tins. This rosaniline has held up remarkably well in all Indian Head powders and has proved to be just what it was intended to be, a *stability indicator*. The first incipient decomposition fades the color entirely away. No rosaniline powder made at Indian Head has been withdrawn from service.

The early days of nitrocellulose powder were attended with many setbacks, lack of stability* oftentimes developing from causes not easy to ascertain. The waste due to this cause led us to make strenuous efforts to utilize

* See *U. S. Naval Institute Proceedings*, Whole No. 136, Vol. 36, No. 4, December, 1910, p. 929, where Commander Strauss discusses the stability question in detail in an article entitled "The Stability of Smokeless Powder."

the unstable and doubtful powders as well as to determine how to make powder so stable that it would never decompose. A method of reworking powder was discovered in 1905 by the Du Pont Company at Carney's Point and after a successful demonstration the process was given to the navy. The navy contributed essentially to the discovery of this reworking process as Patterson successfully applied the dehydration part at Indian Head although Carney's Point had been unable to do this. S. P. 143, a 3"/50 powder, was the one tried and reworked from March to May, 1906. In this case it was remade into a 7" powder and proved excellent. This reworked product is uniformly opaque instead of being translucent as in the case of the new product.

As showing the need that this process supplied it is well to state that in the year ending July, 1913, there were 965,000 pounds of this reworked powder made. In that same year our factory turned out 1,800,000 pounds of new powder and at present date, January, 1914, is making 11,000 pounds per diem.

Because of the long period consumed in drying the powder, thereby causing a delay in the use of powder until practically four months after its manufacture, much energy has been devoted to shortening this drying process. The time *has* been shortened somewhat but all quick methods of drying have proven unsatisfactory to the Navy Department.

A method of water-drying promised well in 1903 but experience with it showed that the grains were unevenly dried and that the per cent of volatiles could not be predicted with uniformity. Raising the temperature very high for short periods while it hastened the drying had a marked deteriorating effect. The system of moderate temperatures and drying in closed circuit dry houses has proven the best method. At one of the German factories 122° F. is attained gradually in drying but our experience shows this to be a mistake as incipient decomposition is generally started. The Du Ponts having successfully dried several lots of powder at 55° C. still are in favor of increasing the temperature of drying.

The uniformity in size, shape, and density of grains continued with great rapidity and these qualities that are so essential to uniform ballistics in the powder have reached a high state of perfection.

In 1909 after much discussion for and against, it was decided to incorporate an organic compound with the powder as a stabilizer. There had been many such used in various countries such as urea, amyl-alcohol, nitroguanadine, and diphenylamine, but reliable reports as to their actual value could not be obtained. The substance chosen as a result of a European trip made by H. F. Brown in 1898 and sample lots made by the Du Ponts in October was diphenylamine $NH\ (C_6H_5)_2$, and the first lot of powder with which that was incorporated was turned out in July, 1909, at our factory and shipped to Olongapo, where it could be subjected to the very worst conditions of storage. The private companies have used it since November, 1908, in all the powder made by them for the government. This experiment has proven a success in every way, all indices thus manufactured being as stable now as when first made. This substance is a basic compound and is a pale yellow solid, it is soluble in alcohol, benzene, or ether and is obtained by heating aniline with aniline hydrochloride at from 250° to 260°. This substance absorbs nitrous vapors readily and thus prevents the generation of more. This action should thus make powder indefinitely stable. Indian Head powder with this substance is still bright and clear, although that from

the private companies is slightly darker and opaque as a rule. This difference in color seems more due to the water used in manufacture than to any other cause. All diphenylamine powders are yellower, particularly around the edges and perforations, than is powder that does not contain it.

Our Ordnance Bureau in 1908 started a testing station for powders in the Philippines which has resulted in keeping powder there in a very satisfactory state, and also has proven many interesting facts, among them being that moisture and varying temperatures in storage are the worst enemies of powder.

Stabillite was an invention of Hudson-Maxim that was sold to the Du Pont Company and by them communicated to the navy. It is a smokeless powder made with non-volatile solvent and is ready for use immediately after granulation, and as such may have a valuable military use in war.

The English cordite, originally made with 53 per cent nitroglycerin, has now been reduced so as to contain but 23 per cent of nitroglycerin, and there is every reason to believe that this cordite would be abandoned for our nitrocellulose powder if it were not for the fact that its adoption would cause such an enormous change in ordnance material that the resulting expense would be beside the question.

The high explosive industry was started by Herman Sprengel,* who observed that every compound capable of internal combustion and every mixture of oxidizing and combustible components can, under the influence of a detonator, be brought to decompose. He started his experiments in 1873 by directing the attention of the explosive industries to picric acid. This had been used only as a dye, but now, so great has become the need for it, its manufacture is in the hundreds of thousands of pounds per year. It is manufactured by the nitration of carbolic acid. The various safety explosives for mines have been on the market since 1886 and Sprengel was the most prominent person in their development. That mining with the safety explosives has become comparatively safe is shown by the fact that in Prussia one death is now caused by the use of each 11,000,000 tons of explosive, whereas in 1895 it was one to every 539,000 tons used.

All navies have experimented with shell fillers, torpedo and mine charges of high explosives. Our service uses Explosive D for shell-burster charges, and this explosive, which was developed by Major B. W. Dunn, U. S. A., has given better results than any of the very numerous shell fillers experimented with up to date. This explosive is perfectly safe to handle, keeping it away from lead salts only, is unaffected by a temperature of as high as 190° continued for a period of 120 days. It is manufactured for both services by the Semet Solvay Company of Syracuse, New York.

For mine and torpedo charges TNT, exhaustively treated of in the Proceedings for June, 1913, page 721, is forging to the fore and bids fair to be soon substituted for our wet and dry guncotton therein. We have been fortunate of late in having a really successful detonating fuse developed that is perfectly safe under all conditions of handling and stowage. Details regarding this and Explosive D are of course held as confidential, though each officer who desires to learn more of them than it is proper to give here may do so through our Bureau of Ordnance.

The foregoing pages have briefly brought out the persons and the events connected the most intimately with the production of our modern navy explosives, and I trust that the main credit has been properly placed. Our

* *Explosives*, Brunswig: Trans. by Munroe and Kibler

service must also bear in mind that each successive inspector of ordnance in charge at Indian Head in conjunction with the powder expert, G. W. Patterson, is primarily responsible for the superb quality of our powder to-day. The quality of the product of our factory is now at least equal to any powder manufactured anywhere. We must accord great credit also to the cooperation of the chemists and the superintendents of the Du Pont Company, several of whom as noted, were trained in the powder business in the early days at Newport, as well as to the naval inspectors of powder who by study and observation have materially assisted in the continual improvement in the processes of the manufacture and the quality of the finished powder.

—*Proceedings of the U. S. Naval Institute.*

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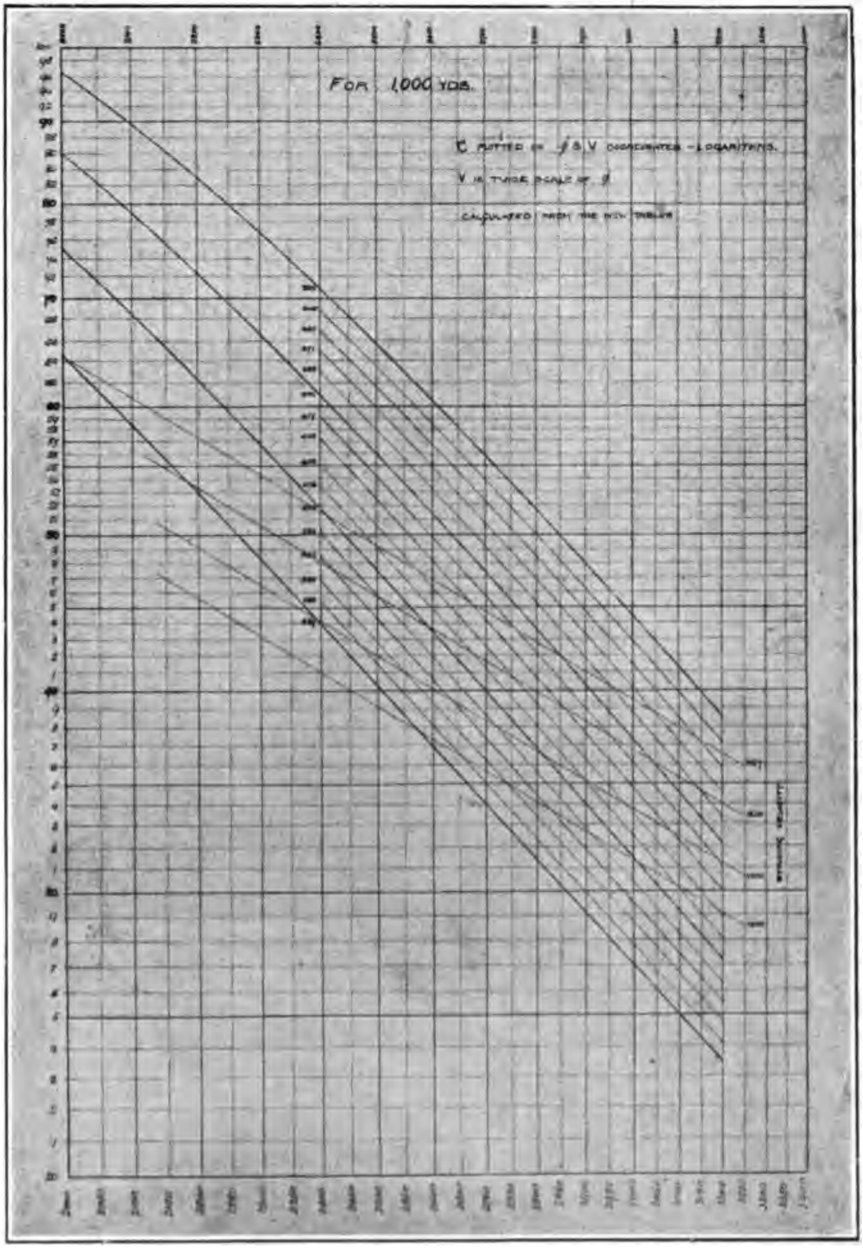
A CHART FOR FINDING "C"

By Captain J. H. HARDCASTLE

Some months ago Captain Hardcastle forwarded to this office a large blue print which he had prepared for his own use. When photographed to a convenient scale, it was still clear and sharp enough for reproduction, so it was decided to publish it for the benefit of those to whose lot falls the recurring task of finding out by trial and error the value of the ballistic coefficient (C) when the true elevation at 1000 yards and the muzzle velocity are known. The formula used in these circumstances is merely the familiar $\sin 2\varphi = a\,C$ where a is looked up in the double entry table on the line marked with the muzzle velocity and taken from the column headed with the value of R over C.

As a rule several attempts have to be made, and when precision is required a certain amount of interpolation is necessary in the tables themselves. To construct the diagram, Captain Hardcastle worked out the angles for velocities 2000, 2400, 2800 and 3200 for values of $\frac{1000}{C}$ from 1500 to 3000, advancing by 100 at a time. He then carefully plotted the resulting figures on a big sheet of good squared paper ruled for logarithms. The numerical work was also shortened by assuming that $\sin 2\varphi$ was precisely equal to $0.000582\ \varphi$, whereby φ was read directly off a 20-inch slide rule, instead of being looked out in a table of natural sines.

After these figures were plotted, it occurred to him to work out the value of C which would give a remaining velocity of (say) 1400 f.s. at 1000 yards for a muzzle velocity of (say) 2800 f.s. by the formula $C = \frac{3000}{S2800 - S1400}$ The values so obtained were joined up by the finer lines marked striking velocity. The fact will be observed that below the striking velocity 1127 f.s. the lines representing φ are practically straight. Above the 1127 f. s. line a curvature can be noticed, the same being caused by the rapid variation in the resistance at the velocity of sound. Those interested in the subject may add for themselves the elevation required when the resistance of the air is neglected, as it could be at this range with heavy ordnance. The formula is $\varphi = \dfrac{R}{6.02\left(\frac{V}{1000}\right)^2}$ or in words' 'The range in yards divided by the square of the muzzle velocity in *thousands* of feet per second, and again divided



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by 6.02 gives the angle of elevation in minutes." This is often useful when zeroing rifles up to 100 yards.—*Arms and Explosives.*

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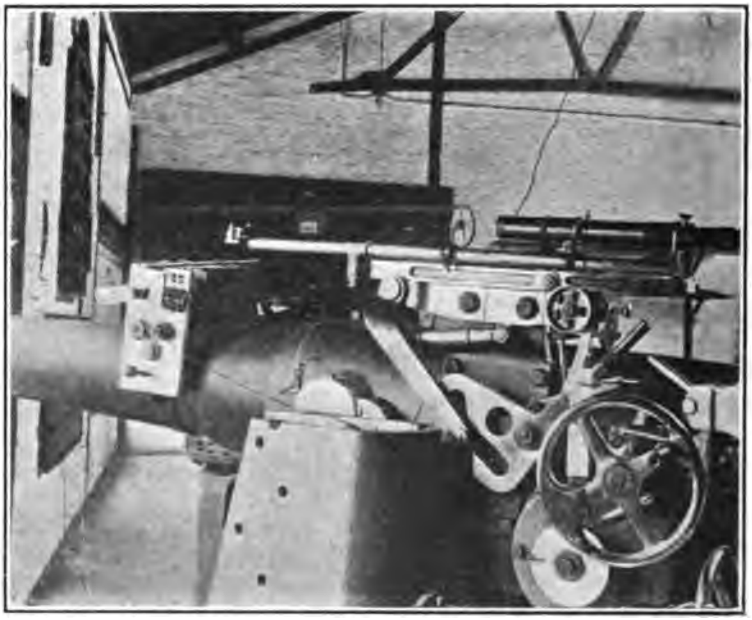
A DEVICE FOR CARRYING OUT MINIATURE GUN PRACTICE

By Lieut. Alan Biddell, Essex and Suffolk R.G.A.

A very cheap and simple arrangement for carrying out miniature gun practice for Coast Defense Companies has been fitted up in the Drill Hall of No. 2 Company Essex and Suffolk R.G.A. at Stratford, and the idea might be very useful to other Territorial Companies of R.G.A. who find it impossible to fit aiming rifles to their guns in the ordinary manner.



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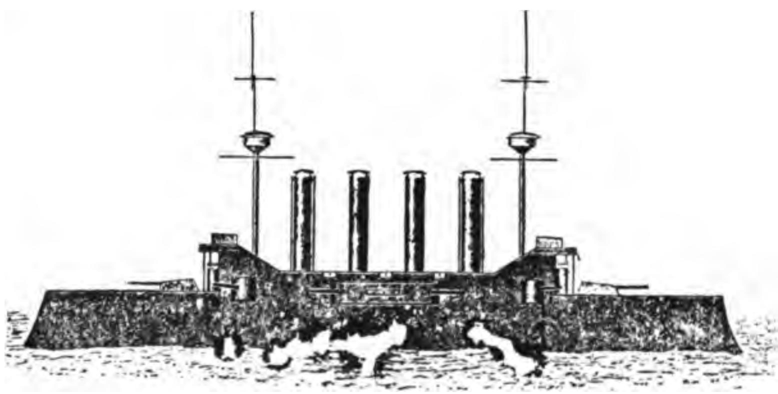
The guns, two 4.7", are mounted close up to the wall in the drill hall with shuttered embrasures, pointing out on to some stables, and as it was out of the question to fire in that direction some other means had to be devised. A small wooden rest was shaped to fit over one of the guns just in front of the trunnions, secured by an iron band with a thumbscrew underneath, on the flat top of which the barrel of a small bolt-action Winchester rifle (with the stock removed) was screwed down pointing at right angles to the axis of the gun, a hole being drilled in the sear of the rifle and a wire attached from this to the trigger of the pistol grip to enable the layer to fire in the usual way.

The targets, representing a four-funnelled cruiser $1\frac{1}{2}$ inches long with $\frac{1}{2}$ inch freeboard, printed on grey paper to make them rather indistinct, run on a carrier on the inside wall of the drill hall parallel to the axis of the

gun and down a slope, making four changes of range during the run. There are five ranges on the elevation indicator marked at intervals of 50 yards corresponding to the angles of elevation necessary to hit the waterline of the cruiser during the run, and to adjust the apparatus for line the bolt of the rifle is taken out and the rifle then layed accurately by looking through the bore. A mirror with a ball socket is fixed on the rocking bar just in front of the telescope, and is then adjusted so as to bring the pointer in the telescope on to the bow water-line of the target, which is reflected in the mirror. If the impression of greater range is required the telescope can be reversed, which makes the laying for line much more difficult. The slope of the target's run being too great for taking ranges with the D.R.F., a large sea picture (a London & North Western Railway poster) is used with a small target, which is connected by pulleys to the hitting target, and the D.R.F. is set up to this with a paper strip on the range drum giving ranges corresponding with the ranges on the elevation indicator.

The six inch loader is in rear of the gun and the detachment man this; only the layers and setters being on the 4.7" with one man to load and cock the rifle. The D.R.F. and dials are manned, recorders used, and the B.C. carries out a complete Case II Series, and as it is quite easy to alter the mirror beforehand to throw the shot out for line and the elevation indicator for range, he must be prepared to correct for both very rapidly, the whole run occupying one minute. Seven or eight rounds can be got off in this time, but this is impossible if the detachment is slow, as the range changes every 15 seconds, and it is remarkable how much quicker the layers are getting since it has been in use.



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To imitate night conditions a small searchlight has been improvised, fitted on the ordinary lighting circuit, all the lights in the hall being switched off, and the elevation indicator lighted by a 4-volt lamp run from the battery box.

As will be seen from the diagram the shooting is very accurate, the system affords good training to the whole group, and excluding ammunition (the .22 short) which is about 9/6 per 1000 rounds, the total cost does not exceed £3 to £5, which, considering the additional interest and spirit of competition aroused in the men, who get rather tired of standing gun drill, may be reckoned as money well spent.

NOTE.—The electric apparatus seen in the photograph is being used for firing the rifle with an electro magnet, and the lamp shown, which is to give a flash when firing under night conditions, will be fixed near the end of the telescope, but at present is only in an experimental stage.

—*The Journal of the Royal Artillery.*

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GUNNERY CHARACTERISTICS OF THE "NORMANDIES"

The 25,300-ton *Normandies* will be remarkable ships from a gunnery standpoint. In addition to their spacious quadruple turrets better fitted in the matter of firing appliances, a revolving turret, forming the upper part of the conning-tower, will afford complete protection for the range-finders, which in previous battleships are left practically unprotected. The military value of such an innovation, which has for some time past been the object of experiments in the gunnery cruiser *Pothuau*, is obvious, and more than makes up for the supplement of displacement it entails. As this is not the only improvement the *Normandies* have received since being placed in hand, these fine ships will be in service slightly heavier than designed, with the exception of the *Béarn*, fifth of the series, on the point of being laid down at La Seyne, which has benefited from a series of minor improvements and will displace a few hundred tons more than her sister ships.

The question of the battle range has become a new topic in naval circles owing to the much-commented on fact that the three general actions fought in the course of the strategic maneuvers occurred in the early hours of the morning, when deficient conditions of visibility caused fire to open between the contending lines of battleships at ranges of 6000 and 8000 meters, thereby depreciating to a certain extent the advantage conferred by heavy calibers. At such distances, it was noted, the volume of fire from 9.4, 7.6, and 6.4-inch guns can play no negligible rôle. As, moreover, last year's maneuvers offered instances of actions fought in semiobscurity, at still closer range. additional arguments are being supplied to those many officers who oppose the increase of size to the detriment of the number of guns on the plea that, whatever merits 15-inch weapons may possess at extreme ranges, they will find in practice few opportunities to utilize to advantage their superior penetration and smashing power. Night operations followed by contests at close quarters at daybreak will become the rule, they hold, in future warfare as the result of the advent of the submarine and aerial factors, which will compel the weaker party to use the cover of night either to force its way through a blockade or to carry out strategic movements such as the effecting of a junction with a friend. And under conditions of that sort, with every chance of fire opening at ranges well under 10,000 meters, 12 guns of 13.4-inch bore are claimed to be worth more than eight of 15 inches. These theories, however, received a severe blow when, in the last part of the maneuvers, Admiralissimo de Lapeyrère, facing with eight dreadnoughts (two *Barts* and six *Dantons*), good for over 18 knots at sea, the 14-knot squadron of Admiral Marin-Darbel (five *Patries* and four older battleships), conclusively demonstrate that a force possessing a substantial superiority for both speed and caliber of heavy guns, and familiarized with maneuvering at full speed in battle formation, will, besides selecting the time and range of the action, be in a position to effect a crushing concentration against the van of

the enemy—a realistic lesson which much impressed those who witnessed it. The distance for a time maintained at 13,000 meters—rather too great for 12- and 9.4-inch weapons—would suit the 15-inch battery of the British *Warspites* and of their German and Italian copies.—From *Naval and Military Record* in *United States Naval Institute Proceedings*.

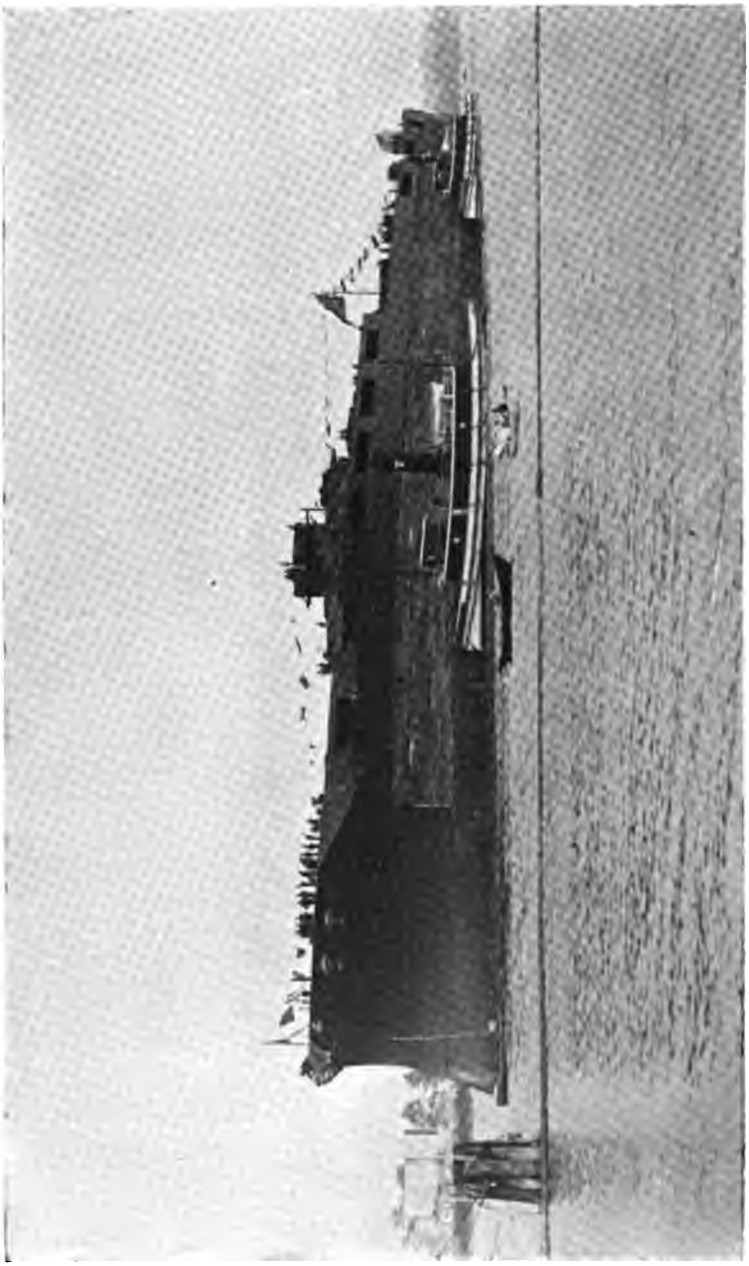
Short Notes

The U. S. S. "Nevada."—The United States battleship *Nevada* was launched at the yard of the Fore River Company, Quincy, on the 11th July, having been twenty months on the stocks. The *Nevada* is the fourth to go afloat of American battleships armed with 14-inch guns, and the second to burn oil exclusively. She is 575 feet long and 95 feet in beam, and will displace 27,500 tons, the designed speed being 20.5 knots with Curtis turbines of 35,000 horse-power. There will be a triple turret forward and aft, and a twin turret superposed in each case, while twenty-one 5-inch will be mounted for defense against torpedo attack.—*United Service Magazine.*

The German Battle-Cruiser "Derfflinger."—The German battle cruiser *Derfflinger*, of the 1911 programme, has just begun her trials and is expected to be ready for commissioning during the autumn. She is 688 feet long on the water-line and 95 feet in beam, with a displacement of 26,600 tons, and is designed for a speed of 26.5 knots with Parsons turbines of 63,000 horse-power. The armament consists of eight 12-inch guns in four center-line turrets, twelve 5.9-inch, and twelve 3.4-inch, together with four submerged 19¾-inch torpedo-tubes. The complement of officers and men is 1125, or 345 more than the British ships of the *Invincible* class, which have the same main armament.—*United Service Magazine.*

New Austrian Battleships.—Authentic details of the new Austrian battleships are now available. They will displace 24,500 tons and will be equipped with 31,000 horse-power turbines, which in two ships will be of the Parsons type and the others *Curtis*. The designed speed is 21 knots. The main armament will comprise ten 13.7-inch guns disposed in the same way as the 14-inch guns of the American *Nevadas*, there being two triple and two twin turrets on the center line, the latter being superposed. The 13.7-inch gun fires a projectile of 1410 lbs. carrying a burster of 79 lbs. of ammonal. Fourteen 5.9-inch and twenty 3.5-inch will also be mounted, the projectiles weighing 112 lbs. and 25 lbs respectively.—*United Service Magazine.*

Trial of a Fuse for an 8-inch A. P. Projectile.—The United States navy is testing a delay action fuse with 8-inch projectiles. This fuse, if exploded accidentally, cannot ignite or explode the charge in the projectile. It will be equally effective against a thin sheet and an armor plate. The delay enables the projectile to pass through as much of the armor plate as it can pierce, or at least penetrate, before explosion takes place. The 8-inch projectile contains three pounds of Dunnite, and, when exploded by the Maxim fuse, gives 500 to 1200 fragments. When the fuse is seated in the projectile, it is not exploded by any shock to which the projectile may be subjected.—*Revue Maritime.*



Photograph by Boston Photo News Co.

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U. S. S. "NEVADA"

Launched July 11, 1914.

(See frontispiece and also page 251.)

Torpedo Tubes.—In common with other navies, notably the Japanese, whose new battle-cruiser, the *Kongo*, has no less than eight torpedo tubes, the French naval authorities are increasing the number of torpedo tubes in their new battleships. The "Danton" class, completed in 1911, and all earlier battleships had only two tubes. The seven vessels of the "Jean Bart" and "Bretagne" type each have four, and in the "Normandie" class, begun last year, there are six. The 18-inch (450-mm.) torpedo which is now in general use in the French Fleet is expected to be followed shortly by one of 21-inch diameter.—*Journal of the Royal United Service Institution.*

Tripod Masts for British Ships.—The tripod mast which some time ago was given up, has once more been resorted to. The new battle cruiser *Tiger* is fitted with one and it is also stated that they will be a feature of the *Queen Elizaoeth* class and presumably also of the new battleships of the *Royal Soverign* class.—*The Navy*,

The U. S. 14-inch Naval Gun.—Here are some of the characteristics of the 14-inch gun, carried by the *New York* and *Texas*. It is 45 calibers in length, that is 52 feet 6 inches. It weighs 63.4 tons, has a muzzle velocity of 2600 feet per second, and fires a shell weighing 1400 pounds. At a distance of 10,000 yards its shell will penetrate over sixteen inches of the hardest Krupp armor. The *Nevada* and *Oklahoma* will carry ten 14-inch guns in four turrets. The *Pennsylvania* and Battleship 39 will carry twelve 14-inch guns in four turrets.—*Army and Navy Journal.*

The German 15-inch Naval Gun.—According to the *Rivista Marittima*, the 15-inch guns of the German battleships of the "Ersatz-Woerth" class have the following characteristics.

Length	45 calibers.
Weight	75 tons.
Weight of projectile	1675.5 lbs.
Weight of charge	531.3 lbs.
Muzzle energy	99.1 foot tons.
Initial velocity	2780 f.s.

The characteristics of the 15-inch guns of other countries are.

Weight of projectile, lbs.	1951	1907	1653
Initial velocity, f.s.	2192	2621	—
Muzzle energy, foot tons.	81.5	91.1	—

—*Revue Maritime.*

Notices

REVOLUTIONARY WAR RECORDS

The United States Government desires to ascertain the whereabouts of all original records, both military and naval, relating to the American Revolutionary War, 1775 to 1783.

This is a matter of great importance to historical students, librarians, institutions of learning, patriotic socities, and all persons interested in their country's struggle for independence.

It is believed that many such records are in the hands of private owners as well as in official archives and libraries. It is not desired to purchase these papers, but to obtain a complete list of them and their location, with a view to publication. Information in regard to all such papers will help complete the record of Virginia's part in the Revolution.

The task of gathering this information in Virginia has been placed in the hands of Mr. Morgan P. Robinson, of Richmond, and Mr. J. H. Lindsay, of Charlottesville.

All persons having knowledge of the existence of such records are requested to write to *Morgan P. Robinson, Historian for War and Navy Departments, care State Library, Richmond, Virginia,* giving a short description of the documents and the post-office address of their owner or custodian.

BOOK REVIEWS

A Text-Book of Military Hygiene and Sanitation. By Frank R. Keefer, A. M., M. D.; Lieut.-Colonel, Medical Corps, U. S. A.; Professor of Military Hygiene, U. S. M. A., West Point, N. Y. Philadelphia: W. B. Saunders Company, West Washington Square. 5¼" x 8¼". 305 pp. 47 il. 1914. Price, $1.50.

This is an excellent text book of military hygiene and sanitation.

The basis of the work is apparently the author's lectures to the cadets at West Point.

The chapter on physical training, written by Captain H. J. Koehler, U.S.A., (Director of Physical Training at the United States Military Academy at West Point) is admirable, and can be read with especial profit by every one.

The usual subjects of military hygiene are respectively taken up in fifteen chapters (in all 282 pages), and the essentials for a practical understanding and working knowledge of each are presented in an instructive manner, well calculated to stimulate interest in and study of this most important part of the training of an officer.

The book is opportune in its appearance, and its adoption as a text-book is recommended for all purely military schools as well as for other institutions of learning that include military training in their courses.

It is thoroughly up to date.

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Elements of Modern Field Artillery, U. S. Service. By Major Harry G. Bishop, 5th Field Artillery (Formerly Instructor, Department of Military Art, Army Service Schools, Fort Leavenworth, Kansas). Menasha, Wisconsin: George Banta Publishing Company 9¼" x 6". 135+10 pp. 5 il. 1 map. 1914. Price, $1.50 postpaid.

This book comprises within a comparatively few pages the non-technical characteristics of the field artillery arm.

As stated in the introductory chapter, the book is not a "field artilleryman's text-book"; but is "intended solely as a reference for the layman." This purpose the author has accomplished most satisfactorily.

The subject matter is well arranged. The opening chapters give a description of the general characteristics of the field artillery arm, its matériel and organization. This is followed by chapters describing the maneuvering of field artillery units, the service of information, and the conduct of fire. Finally, the employment of field artillery in active operations is treated of.

An excellent feature is the last chapter, in which is given the leading of a battalion of field artillery previous to and during a combat. This places before officers from other arms an illustration of the manner in which the field artillery go into action, and also serves to illustrate to commanders of all grades and arms some of the means by which they may forward the intimate cooperation of the field artillery with the infantry it is supporting.

Major Bishop's book is very readable and fills a long felt want in the service for a book which gives within small compass the information about field artillery which is essential to officers of other arms.

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Einfuhrung in die Gebrauchnahme des Batterierichtkreises M.5 und der Geschutzrichtkreise (-fernrohre) M.8 und 9. By Hauptmann L. Grossmann, Lehrer an der k.u.k. Technischen Militarakademie Im Selbstverlage des Verfassers und in Kommission bei L. W. Seidel & Sohn, k.u.k. Hofbuchhandler in Wien 1, Graben 13. 4¾" x 7¼". 98 pp. Paper. 1914.

As an introduction to the fire control system of the field artillery, the author of this practical little treatise describes the solution of triangles by trigonometrical methods. Following this he presents in detail and in very simple terms the theoretical and practical use of the instruments employed in indirect fire, both at the firing point and at the point from which the target is visible. An important feature of the book is the clear exposition of the errors in range and direction arising from errors in observation. The book concludes with tables for the solution of triangles, the argument being in mils. The explanations throughout are clear, and the numerous diagrams add greatly to the value of the book as a means of instruction in the use of field artillery fire control instruments.

♣ ♣ ♣

Tactics and the Landscape. By Captain T. Bedford Franklin; illustrated by M. M. Williams. London: Gale & Polden, Ltd., 2 Amen Corner, Paternoster Row. 5¾" x 8½". 56 pp. 9 plates. Cloth. 1914. Price, 3 shillings net.

The purpose of the work is to enable one to answer the important questions, "What could I see from here?" and "What could the enemy see from there?"

It is accomplished in eight chapters, in which are described in detail the march of a company acting as advance guard for a battalion, encountering the enemy, beginning the attack, reinforcing, ammunition supply, the assault, the advance to and occupation of a position, the conduct of a patrol, the counter attack, and the retreat on the one side; and, on the other in the same action, scouts, formations through woods, advancing to a crest under fire, crossing a river, occupying of quarters in a village at night, and outposts.

Accompanying and illustrating the text are a small typographical map, two inches to the mile, and nine sketches in which are developed in landscape form the features of the country represented on the map which figure prominently in the course of the action.

It is believed the method is a good one for teaching map reading and it is here presented in an interesting manner.

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Index to Current Military Literature

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1914

KEY

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The periodicals cited are arranged by government, and each periodical is assigned a symbol consisting of an initial, or other abbreviation of the governmental designation, and a numeral indicative of the periodical's position in an alphabetical arrangement of the JOURNAL OF THE UNITED STATES ARILLERY, exchanges under that government.

Prices of subscription are given in the currencies of the countries of publication.

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ARGENTINE

Ar-0.5	*Anuario del Instituto Geografico Militar de la Republica Argentina*	
	3ª Division del Estado Mayor del Ejército	Annual
	Buenos Aires	
Ar-1	*Boletin del Centro Naval*	Bimonthly
	Florida 659, Buenos Aires	Per year $\$^{m}/_{n}$11.90
Ar-1.5	*Revista del Circulo Militar*	Monthly
	255 Maipu	Per year $12.00
	Buenos Aires	
Ar-2	*Revista Militar*	Monthly
	Ministerio de Guerra, Santa Fe 1461	Per year $\$^{m}/_{n}$9.00
	Buenos Aires	

AUSTRIA

Au-1	*Mitteilungen aus dem Gebiete des Seewesens*	Monthly
	Pola	Per year 17 M
Au-2	*Mitteilungen ueber Gegenstaende des Artillerie-und Genie-Wesens*	
	Getreidemarkt 9	Monthly
	Wien, VI.	Per year 20 M
Au-3	*Streffleurs Militaerische Zeitschrift zugleich Organ der militaerwissenschaftlichen Vereine*	Monthly
	I. Graben, 13. Wien	Per year 28 M
Au-3.5	*Streffleurs Militaerblatt*	
	Verlag L. W. Seidel & Sohn, k.u.k	Weekly
	Hofbuchhandler, Wien	Per year 16 M
Au-4	*Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*	
	I. Eschenbachgasse, No. 9	Weekly
	Wien	Per year 34 K

BELGIUM

Be-1	*Belgique Militaire, La*	Weekly
	Rue Albert de Latour 50	Per year 12 fr 50
	Schaerbeck, Brussels	

Be-2	*Revue de l'Armée Belge* 24 Rue des Guillemins, Liege	Bimonthly Per year 13 fr
Be-3	*Revue de l'Ingénieur et Index Technique* 70, Boulevard d'Anderlecht, Brussels	Quarterly Per year 30 fr

BRAZIL

Br-1	*Boletim Mensal do Estado Maior do Exercito* Ministerio de Guerra Rio de Janeiro	Monthly
Br-2	*O Tiro* Rio de Janeiro	Monthly
Br-3	*Revista Maritima Brazileira* Rua D. Manoel n. 15 Rio de Janeiro	Monthly Per year 12$000

CHILE

C-1	*Memorial del Estado Mayor del Ejercito de Chile* Talleres del Estado Mayor-General Santiago	 Monthly
C-2	*Revista de Marina* Casilla del Correo 976, Valparaiso	Monthly Per year $15.00

COLOMBIA

Co-1	*Memorial del Estado Mayor del Ejercito de Colombia* Jefe del Departamento de Historia del Estado Mayor-General Bogota	 Bimonthly Per year $0 50 oro

DENMARK

D-0.5	*Dansk Artilleri-Tidsskrift* Copenhagen	Bimonthly Per year 5 kr
D-1	*Militært Tidsskrift* Copenhagen	Semimonthly Per year 8 kr

DOMINICAN REPUBLIC

DR-1	*El Porvenir Militar* Salome Urena No. 8 Santo Domingo	Monthly

ECUADOR

E-1	*Boletin del Estado Mayor General* Quito	Monthly Per year $4.00

FRANCE

F-1	*Archives Militaires, Les* Librairie Militaire Berger-Levrault 5-7 Rue des Beaux-Arts, Paris	Quarterly Per year 14 fr
F-2	*France Militaire, La* 10 Rue Danton, Paris	Daily Per year 32 fr
F-3	*Génie Civil, Le* 6 Rue de la Chaussée d'Antin, Paris	Weekly Per year 45 fr
F-4	*Journal des Sciences Militaires* 30 Rue Dauphine, Paris	Weekly Per year 40 fr

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	Librairie Chapelot 30 Rue et Passage Dauphine, Paris	Per year 15 fr
F-16	*Yacht, Le, Journal de la Marine*	Weekly
	55 Rue Chateaudun, Paris	Per year 32 fr

GERMANY

G-1	*Artilleristische Monatshefte*	Monthly
	Bernburgerstr. 24-25 Berlin, S. W. 11	Per year 27 M
G-2	*Eisen-Zeitung*	Weekly
	Verlag von Otto Elsner, Berlin, S. 42	Per year 12 M
G-3	*Ingenieur, Der*	Semimonthly
	Verlag Buchdruckerei F. Posekel, Gneisenaustrasse 67, Berlin S. 61,	Per year 16 M
G-3.5	*Kriegstechnische Zeitschrift*	10 Nos. per yr.
	E. S. Mittler & Sohn Königliche Hofbuchhandlung, Kochstrasse, 68-71, Berlin, S. W.	Per pear 10 M.
G-4	*Marine Rundschau*	Monthly
	Koch Strasse, 68-71, Berlin, S.W.	Per year 10 M
G-5	*Militaer Wochenblatt*	3 times a week
	With monthly Supplement Koch Strasse, 68, Berlin, S.W., 12	Per year 18 M
G-6	*Schiffbau*	Semimonthly
	Zimmerstr. 9, Berlin, S.W., 68	Per year 20 M
G-8	*Ueberall*	Monthly
	Verlag: Boll und Pickardt Berlin, N.W. 7	Per year 15.6 M

G-9	*Zeitschrift fuer das Gesamte Schiess-und Sprengstoffwesen* J. F. Lehmann's Verlag, Paul Heysestrasse 26, Munich	Semimonthly Per year 26 M

HOLLAND

H-1	*Orgaan der Vereeniging ter beoefening van de Krijgswetenschap* Z. O. Buitensingel 224 The Hague	Six Nos. per yr. Per year 4 florins
H-2	*Wetenschappelijk Jaarbericht. Vereeniging ter beoefening van der Krijgswetnschap* Z. O. Buitensingel 224 The Hague	Yearly Per year 2 florins

ITALY

I-1	*Lista Navale Italiana* Officina Poligrafica Italiana, Rome	Quarterly Per year 15 L
I-2	*Rendiconti delle Esperienze e Degli Studi Eseguiti Nello Stabilimento di Esperienze e Costruzioni Aeronautiche del Genio* Viale Giulio Cesare N. 2, Rome	Occasional Per year 13.50 L
I-3	*Rivista di Artiglieria e Genio* Tipografia Enrico Voghera Via Astalli 15, Rome	Monthly, ex. July Per year 20 L
I-4	*Rivista Marittima* Officina Poligrafica Italiana Rome	Monthly Per year 25 L

MEXICO

M-1	*Boletin de Ingenieros* War Dept., Mexico City	Monthly
M-2	*Revista del Ejercito y Marina* Departamento de Estado Mayor City of Mexico	Monthly

NORWAY

N-1	*Norsk Artilleri-Tidsskrift* Christiania	Bimonthly Per year 6 kr
N-2	*Norsk Militært Tidsskrift* Christiania	Monthly Per year 8 kr

PERU

Pe-1	*Boletin del Ministerio de Guerra y Marina* Apartado de Correo No. 91, Lima	Fortnightly

PORTUGAL

Po-1	*Anais do Club Militar Naval* 43 Rua do Carmo, Lisbon	Monthly Per year 4$200
Po-2	*Revista de Artilharia* Rua do Carmo, 43, 2°., Direito, Lisbon	Monthly Per year 3$000 rs
Po-3	*Revista de Engenharia Militar* 27 Rua Nova do Almada, Lisbon	Monthly Per year 3$600 rs
Po-4	*Revista Militar* Largo da Annunciada, 9, Lisbon	Monthly Per year 3$000 rs

RUSSIA

R-1	*Imperial Nicholai War Academy Recorder, The* St. Petersburg	Monthly Per year 6 rubles
R-2	*News of the Officers' Artillery School* Zarskoye Selo	Monthly Per year 10 rubles

SPAIN

Sp-1	*Informacion Militar del Extranjero* Talleres del Deposito de la Guerra Madrid	Monthly
Sp-2	*Memorial de Artilleria* Museo de Artilleria, Madrid	Monthly Per year 18 ps
Sp-3	*Revista Cientifico-Militar* Paseo de San Juan, 201, Barcelona	Semimonthly Per year 40 ps
Sp-4	*Revista General de Marina* Ministerio de Marina, Madrid	Monthly Per year 25 ps

SWEDEN

Sn-1	*Artilleri-Tidsskrift* Artillerigarden, Stockholm	Bimonthly Per year 6 kr
Sn-2	*Svensk Kustartilleritidskrift* Karlskrona	Quarterly Per year 6 kr

SWITZERLAND

Sd-1	*Allgemeine Schweizerische Militarzeitung* Basel	Weekly Per year 10 fr
Sd-2	*Revue Militaire Suisse* Avenue Juste Olivier, Lausanne	Monthly Per year 15 fr
Sd-3	*Schweizerische Monatschrift fuer Offiziere Aller Waffen* Frauenfeld	Monthly Per year 5 fr
Sd-4	*Schweizerische Zeitschrift fuer Artillerie und Genie* Frauenfeld	Monthly Per year 8 fr

UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ITS COLONIES AND POSSESSIONS

UK-1	*Arms and Explosives* Effingham House Arundel Street, Strand, London, W.C.	Monthly Per year 7s
UK-3	*Army Review, The* Wyman & Sons, Ltd. Fetter Lane, London, E. C.	Quarterly Per copy 1s
UK-4	*Canadian Military Gazette* Room 16, Trust Bldg. Ottawa, Canada	Semimonthly Per year $2.50
UK-5	*Commonwealth Military Journal, The* Melbourne, Australia	Quarterly
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UK–8	*Engineer, The* 33 Norfolk Street, Strand London, W.C.	Weekly Per year £1 16s
UK–9	*Engineering* 35-36 Bedford Street, Strand London, W.C.	Weekly Per year £1 16s
UK–10	*Iron & Coal Trades Review, The* 165 Strand, London, W. C.	Weekly Per year 27s
UK–10.5	*Journal of the Institution of Mechanical Engineers, The* Storey's Gate, St. James Park London, S. W.	8 Nos. per year
UK–11	*Journal of the Royal Artillery, The* Woolwich	Monthly Single copy 2s 6d
UK–12	*Journal and Proceedings, Royal Society N. S. W.* 5 Elizabeth St., North Sydney, N. S. W.	
UK–13	*Journal of the Royal United Service Institution* Whitehall, London, S.W.	Monthly Per year 24s
UK–14	*Journal of the United Service Institution of India* Simla, India	Quarterly Per year Rs 8
UK–15	*Junior Institution of Engineers, The* 39 Victoria St., Westminster, S.W. London	Monthly Single copy 1s
UK–17	*Page's Engineering Weekly* 22 Henrietta Street, Covent Garden London, W. C.	Weekly Per year £1 1s
UK–18	*Photographic Journal* 35 Russell Square, London	Occasional Copies 1s each
UK–19	*Proceedings of the Institution of Civil Engineers* Great George St., Westminster, London, S. W.	
UK–20	*Proceedings of the Institution of Mechanical Engineers* Story's Gate St., James Park, London, S. W.	
UK–21	*Royal Engineers Journal, The* Chatham	Monthly Per year 15s
UK–22	*Transactions of the Canadian Institute* 58 Richmond Street, Toronto, Canada	
UK–23	*Transactions of the Canadian Society of Civil Engineers* 176 Mansfield Street Montreal, Canada	
UK–24	*Transactions of the Institution of Naval Architects* 5 Adelphi Terrace, London, W. C.	
UK–25	*United Service Gazette* Caxton House, 11 Gough Square, Fleet Street, London, E. C.	Weekly Per year £1 10s 6d
UK–26	*United Service Magazine* 31, Haymarket London, S. W.	Monthly Per year £1 1s

UNITED STATES

US–1	*Aeronautics* 250 West 54th Street, New York City	Semimonthly Per year $3.00

US–2L	*American Historical Review, The* The Macmillan Company 41 N. Queen Street, Lancaster, Pa., or 66 Fifth Avenue, New York City	Quarterly Per year $4.00
US–3L	*American Journal of International Law, The* Baker, Voorhis & Co., 45 John St., N.Y.	Quarterly Per year $5.00
US–4	*American Journal of Mathematics* Johns Hopkins Press Baltimore, Md.	Quarterly Per year $5.00
US–5	*Arms and The Man* 1502 H Street, N.W., Washington, D. C.	Weekly Per year $3.00
US–6	*Army and Navy Journal* 20 Vesey Street, New York	Weekly Per year $6.00
US–7	*Army and Navy Register* Washington, D. C.	Weekly Per year $3.00
US–8	*Bulletin of the American Geographical Society* Broadway at 156th Street, New York City	Monthly Per year $5.00
US–10	*Bulletin of the American Mathematical Society* 501 West 116th Street, New York	Ten Nos. per yr. Per year $5.00
US–11	*Bulletins and Circulars of the Bureau of Standards* Department of Commerce and Labor Washington, D. C.	
US–12L	*Bulletin of the Pan American Union* Seventeenth and B Streets, N.W. Washington, D. C.	Monthly Per year $2.00
US–13	*Bulletin of Iowa State College* Ames, Iowa	Monthy
US–14	*Bulletin of the University of Illinois* Urbana, Illinois	
US–15	*Bulletins, Circulars and Technical Papers* *Bureau of Mines* Department of the Interior Washington, D. C.	Occasional Free
US–16L	*Canal Record* Ancon, Canal Zone, Isthmus of Panama	Weekly Per copy 5c
US–17.5	*Colliery Engineer, The* Scranton, Pa.	Monthly Per year $2.00
US–17.75 L	*Colonial Wars* 9 Ashburton Place Boston	Quarterly Per year $3.00
US–18	*Compressed Air Magazine* Compressed Air Magazine Co. Easton, Pa.	Monthly Per year $1.50
US–19	*Confederate Veteran* Nashville, Tenn.	Monthly Per year $1.00
US–20	*Craftsman, The* 41 W. 31th Street, New York	Monthly Per year $3.00
US–21	*Electric Journal, The* 200 Ninth Street, Pittsburgh, Pa.	Monthly Per year $1.50

US–22	*Electrical Review and Western Electrician* Heisen Building 608 South Dearborn Street, Chicago	Weekly Per year $3.00
US–23	*Electricity and Engineering* 608 South Dearborn Street, Chicago, Ill.	Monthly Per year $1.00
US–24	*Engineering Magazine, The* 140-142 Nassau Street, New York	Monthly Per year $3.00
US–25	*Engineering News* 505 Pearl Street, New York	Weekly Per year $5.00
US–27	*Field Artillery Journal, The* U. S. Field Artillery Association 1701 Pennsylvania Avenue, N.W. Washington, D.C.	Quarterly Per year $3.00
US–28	*Flying and The Aero Club of America Bulletin* 297 Madison Ave., New York	Monthly Per year $3.00
US–29	*General Electric Review* General Electric Company Schenectady, New York	Monthly Per year $2.00
US–30	*Infantry Journal* U. S. Infantry Association 814 Seventeenth Street, N.W Washington, D. C.	Bimonthly Per year $3.00
US–31L	*Journal of American History, The* 3 West 43rd Street, New York	Quarterly Per year $3.00
US–31.5	*Journal of Efficiency Society, Inc.* 29 West 39th Street, New York City	Monthly Per year $3.00
US–33	*Journal of The American Society of Mechanical Engineers, The* 29 West 39th Street, New York City	Monthly Per year $3.00
US–34	*Journal of the American Society of Naval Engineers* Navy Department, Washington, D.C.	Quarterly Per year $5.00
US–35	*Journal of the Association of Engineering Societies* 3817 Olive Street, St. Louis, Mo.	Monthly Per year $3.00
US–36	*Journal of the Franklin Institute* 15 South Seventh Street, Philadelphia, Pa.	Monthly Per year $5.00
US–37	*Journal of the Military Service Institution* Governor's Island, New York	Bimonthly Per year $3.00
US–38	*Journal of the U. S. Artillery* Fort Monroe, Virginia	Bimonthly Per year $2.50
US–39	*Journal of the U. S. Cavalry Association* Fort Leavenworth, Kansas	Quarterly Per year $2.50
US–40	*Journal of the Western Society of Engineers* 1735 Monadnock Block Chicago, Illinois	Monthly ex. July and Aug Per year $3.00
US–41	*Machinery* 49-55 Lafayette Street, New York	Monthly Per year $2.50

US–42	*Metal Industry, The* 99 John Street, New York	Monthly Per year $1.00
US–43	*Military Surgeon, The* 535 North Dearborn Street Chicago, Illinois	Monthly Per year $3.50
US–45L	*National Geographic Magazine, The* Hubbard Memorial Hall Washington, D. C.	Monthly Per year $2.50
US–46	*National Guard Magazine, The* 136-140 East Gay Street Columbus, Ohio	Monthly Per year $1.00
US–47	*Navy, The* Southern Building Washington, D. C.	Monthly Per year $2.00
US–47.5L	*North American Review, The* The North American Review Publishing Company New York City	Monthly Per year $4.00
US–48	*Official Gazette of the United States Patent Office, The* Supt. of Documents, Gov. Printing Office Washington, D. C.	Weekly Per year $5.00
US–49	*Pennsylvania Magazine of History and Biography* Philadelphia, Pa.	Quarterly Per year $3.00
US–50	*Physical Review* 41 North Queen Street, Lancaster, Pa.	Monthly Per year $6.00
US–51	*Polytechnic, The* Troy, N. Y.	10 Nos. per yr. Per year $2.00
US–52	*Popular Mechanics* 6 N. Michigan Boulevard, Chicago, Ill.	Monthly Per year $1.50
US–54L	*Proceedings of the American Institute of Electrical Engineers* 33 West 39th Street New York	Monthly Per year $10.00
US–55	*Proceedings of the American Philosophical Society* 104 South Fifth Street, Philadelphia, Pa.	
US–56	*Proceedings of the American Society of Civil Engineers* 220 West 57th Street New York	10 Nos. per year Per year $8.00
US–57	*Proceedings of The Engineers' Club of Philadelphia* 1317 Spruce Street Philadelphia, Pa.	Quarterly Per Vol. $2.00
US–58	*Proceedings of The Engineers' Society of Western Pennsylvania* 2511 Oliver Building Pittsburgh, Pa.	10 Nos. per year Per year $5.00
US–59	*Proceedings of the U. S. Naval Institute* Annapolis, Md.	Bimonthly Per year $3.00
US–60	*Professional Memoirs* Washington Barracks, D. C.	Bimonthly Per year $3.00
US–61	*Reactions* Goldschmidt Thermit Company 90 West Street, New York	Quarterly Per year $0.25

US–64	*Science Conspectus* Massachusetts Institute of Technology Boston, Mass.	Five issues per yr.
US–65	*Scientific American* 361 Broadway, New York	Weekly Per year $3.00
US–66L	*Scientific American Supplement* 361 Broadway, New York	Weekly Per year $5.00
US–68	*Seventh Regiment Gazette, The* 30 West 33rd Street, New York	Monthly Per year $1.50
US–71	*Stevens Indicator* Stevens Institute of Technology Hoboken, N. J.	 Quarterly Per year $1.50
US–73	*Telephone Engineer* Monadnock Building, Chicago, Ill.	Monthly Per year $2.00
US–74	*Transactions of the American Society of Civil Engineers* 220 West 57th Street, New York	 Yearly Per year $12.00
US–75	*Transactions of the Society of Naval Architects and Marine Engineers* 29 West 39th Street, New York	Annual
US–76L	*Virginia Magazine of History and Biography, The* Virginia Historical Society Richmond, Va.	 Quarterly Per year $5.00

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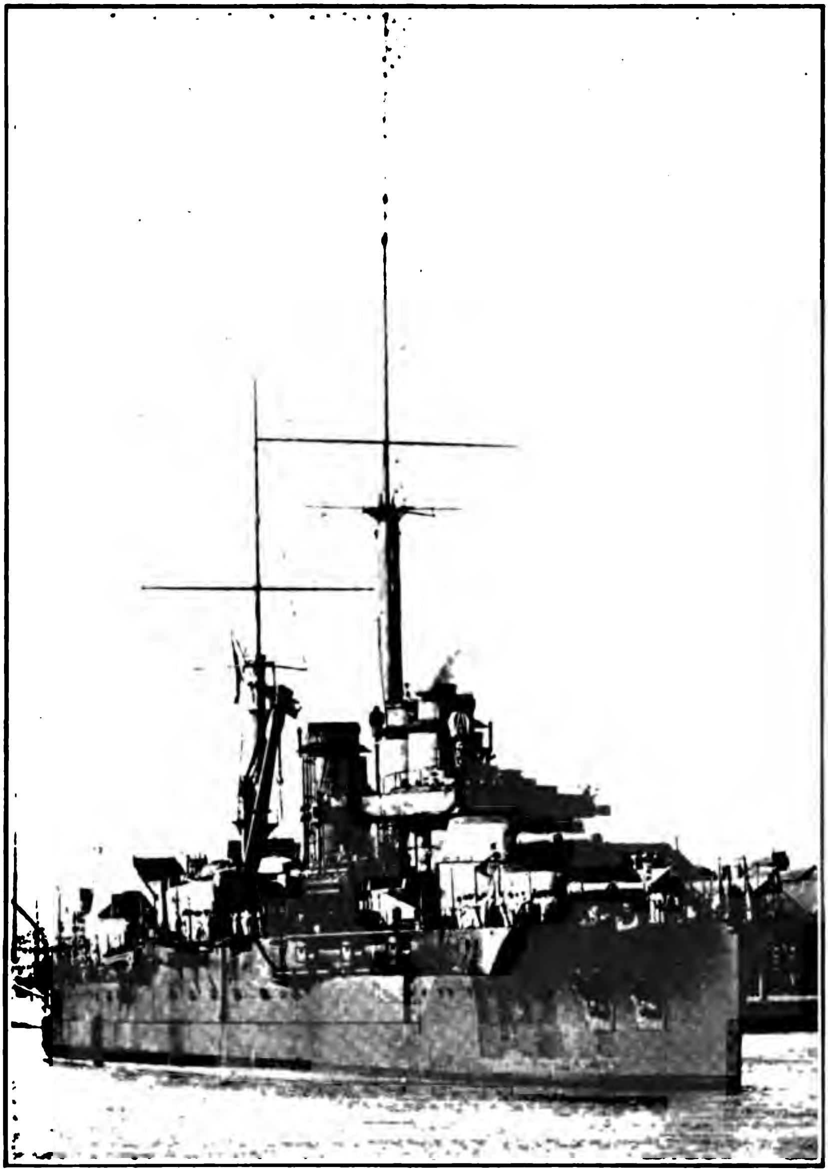

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FRENCH DREADNOUGHT "LA FRANCE"

Displacement, 23,467 tons; length (*p.p.*), 541⅓ ft.; beam, 88½ ft.; maximum draught, 29½ ft. Armament: twelve 12-inch, 50-cal.; twenty-two 5 5-inch, 45-cal.; four 18-inch torpedo tubes. Armor: belt, 10¾ in.; turrets, 12½ in.; deck, 2¾ in. Designed horsepower, 28,000; speed, 21 knots.—Jane.

JOURNAL

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THE DEVELOPMENT OF COAST ARTILLERY GUNNERY IN THE UNITED STATES DURING TWENTY YEARS

By MAJOR JAMES M. WILLIAMS, COAST ARTILLERY CORPS

For the purpose of indicating a general direction and of establishing a relationship between gunnery and other departments of the profession of coast artillerist, it is well to begin with a few definitions.

Gunnery, ballistics, practice, and fire control are all very closely allied terms in modern coast artillery. Considering primary definitions, gunnery is the general term, "the science and art of operating cannon" (*New Standard Dictionary*); ballistics, "the science that deals with the impact, path, and velocity of projectiles" (*ibid*); practice, "frequent and repeated exercise * * * to gain experience or skill" (*ibid*); fire-control, "a system for regulating and controlling the fire of the guns * * * in fortifications" (*ibid*). But secondarily, in our service, the term gunnery is used with specific reference to the domain of "the science and art of operating cannon" which lies outside ballistics and fire control. In this sense, gunnery might be defined as the science and art of so regulating the fire of cannon as to secure a maximum of hits out of a given number of shots fired.

While, therefore, the science of gunnery might be said to begin where the science of ballistics leaves off, and the art of gunnery might be said to be based upon the matériel of fire control, no such distinction appears between gunnery and

practice: the two go hand in hand. Indeed, in the regulation of the fire of cannon with a view to securing the maximum of hits, we are concerned with three factors: the personnel, the matériel, and the theory, laws, or rules according to which the personnel and matériel are employed. And, in the last refinement, or specialization, of the term gunnery, it is this theory, these laws or rules, to which it applies; and these laws or rules are found in our target practice regulations: for, *whether so intended or not, every regulation prescribed for target practice affects, or itself becomes, a law of gunnery.*

A review of the development of gunnery will, therefore, necessitate a study of the target practice regulations.

In 1892, at the time of the founding of the JOURNAL OF THE UNITED STATES ARTILLERY, the general regulations governing coast artillery target practice were found in Tidball's *Manual of Heavy Artillery Service*, and the special regulations in General Orders No. 108, A.G.O., December 7, 1888.

Par. 401 of Tidball's Manual stated the purpose of target practice to be, "to test, from actual observation, the effective power of the piece, and to acquire skill in utilizing this power."

From General Orders No. 108 of 1888 we learn that the pieces of ordnance used in coast artillery target practice were: the 15-inch and 10-inch smooth-bore guns, the 8-inch converted, muzzle-loading rifle; and the 13-inch and 10-inch mortars. For the 15-inch gun the annual allowance of ammunition to one organization was four solid shot with hexagonal powder; for the 8-inch rifle, the allowance was six projectiles. One half of the allowance in each case was to be fired at fixed targets at each of two definitely fixed ranges, 1700 and 2700 yards. Each non-commissioned officer was required to fire a *pro rata* number of the shots allowed; and in order that, to that end, all might be present at the gun, observers at the ends of the base line, plotters, etc., were required to be taken from organizations other than the one firing.

As means to accuracy, the powder was required to be "mixed"; anemometer, thermometer, and barometer readings to be taken; and rammer staves marked to insure uniform position for the cartridge and projectile.

As a means of training the personnel in fire regulation, officers and men were required to note the lateral deviation of each shot and compare it with the deviation determined by means of a transit established in rear of the gun.

The recorded data of the firing were afterwards plotted

upon sheets ruled in squares corresponding to the squares of the harbor charts, and the mean absolute deviation was used in determining the figure of merit—"although," the order states, "variations in range are much less under the control of the gunner than lateral deviations, which should therefore have a greater relative value in determining marksmanship."

With some modifications of details, such as the calibers to be used in practice, the allowance of ammunition, and the range, General Orders No. 108 of 1888 remained in force till 1897, when General Orders No. 41, of September 4, 1896, became effective.

As an aid in forming a mental picture of the state of gunnery in 1892, it is useful to consider the course in gunners' instruction then established. General Orders No. 108 prescribed that the non-commissioned officers and "such privates as may be able to learn" should be taught "the *principles* of graduating sights, pointing guns and mortars, and the causes which affect the flight of the projectile, especially those due to improper loading, the rifling, and the wind." And General Orders No. 132 of November 18, 1890, prescribed as follows: "In order to encourage excellence in gunnery and in preliminary instruction of individuals and batteries among the heavy artillery troops of the Army, the following scheme of competitions is, with the approval of the Secretary of War, hereby adopted."

The scheme included three grades of competitions:

1. Battery competition.
2. Regimental competition.
3. General artillery competition.

The battery competition was held annually after the target practice season by three regimental officers who classified "gunners" in each battery of the regiment according to relative excellence of preliminary instruction. The subjects included in the test for classification were:

a. Setting and reading quadrants and angle measuring instruments, and using the plotting board.

b. Service of the piece for available siege and seacoast armament.

c. Judging distances to fixed objects.

d. Judging distances to moving objects.

e. Judging speed of vessels.

f. Judging velocity of wind.

g. Laying guns.
h. Cordage, blocks, etc.

The regimental competition was between selected teams from the batteries of the regiment, and comprised three stages:

1st. Individual instruction.
2nd. Service of the piece.
3rd. Competitive firing with the 8-inch converted muzzle-loading rifle and 15-inch smooth bore gun, or such more modern ordnance as might be available.

In the general artillery competition were entered the battery teams which won their respective regimental competitions. The character of the competition was the same as that of the regimental.

From a consideration of the development of gunnery in the United States in 1892 as disclosed by the records, we conclude that the principles were well establised, and, in matters more directly related to ballistics, applied. But, since only fixed targets were fired at, rules of gunnery for moving targets were not developed; while we have no indication as to how, even in the case of fixed targets, the principle, recognized in basing the figure of merit upon the mean absolute deviation, was to be applied for the purpose of attaining the maximum number of hits out of the number of shots allowed for the practice. Other than the exercise of officers and men in estimating lateral deviation, the only reference to correction of fire that can be found, is on page 191 of Tidball's Manual, where is stated: "The officer at each station is accompanied by a flagman to signal to the piece whether the shots are *short*, or *over*. By this means the error, for subsequent shots, is approximately corrected."

It appears, then, from the object of target practice as stated in the manual, as well as from the rules prescribed for execution and the instruction prescribed for gunners, that practice was considered almost wholly from the point of view of ballistics—it was an exercise in ballistics rather than in gunnery, as specifically defined. For this, there were many reasons; amongst others being the use of fixed targets, the lack of fire control matériel, and the use of a stable powder.

Of the methods of gunnery for use in firing at moving targets contemplated about this time, we form an idea from the following extract, concerning David's Island (Fort Slocum) in 1894, from *The Evolution of Our System of Position Finding*

and Fire Control, by Captain H. L. Morse, C. A. C., in the JOURNAL for March-April, 1913:

INSTRUCTIONS FOR FIRING AT MOVING VESSELS

I. Estimate the distance to the vessel; give the general direction to the piece; and set the sight at the elevation required for the distance.

II. Estimate the speed of the vessel *in direction perpendicular to the line of fire*, in yards per second. To the time of flight in seconds, add five seconds to allow for the gunner's getting down from the piece and firing after the command "Ready," and calculate the number of yards the vessel will move in the above mentioned direction in this time. Turn this into points of the deflection scale (wind gauge).

III. Make a rapid estimate as to the strength and direction of the wind, and calculate the number of points to allow for it. To this result add the allowance for drift if the wind is from the left; subtract it if the wind is from the right.

IV. Combine III and II, adding or subtracting according to the direction in which the vessel is moving, and place the result on the deflection scale. Make a final estimate of the distance to the vessel, and if necessary change the elevation to correspond. Have the gun traversed just ahead of the vessel; give the command "Ready" the instant her foremast comes into line; and "Fire" five seconds later.

When a period of time equal to the time of flight has elapsed after the command "Fire," the line of metal must be exactly on the foremast of the vessel, or the work on the deflection scale has not been correctly done. The accuracy of the estimated range must be verified by the use of some one of the range finding instruments, the signal for taking the angles to be given at the same instant that the test for deflection is made.

It is not difficult to picture the lack of success that would have attended at that time attempts to fire at a moving ship of "the enemy."

General Orders No. 41, September 4, 1896, which became effective in 1897, prescribed practice with such breech-loading seacoast guns and mortars as might be available; and, in the absence of such, with the 8-inch converted muzzle-loading rifle. Where the 10-inch and 15-inch smooth bore guns formed a part of the armament, additional practice was to be had with them.

The ranges at which practice was held under General Orders No. 41 were fixed by Department Commanders. Those prescribed for 1897, 1898, 1899, and 1900, in the Department of the East were as follows:

	1897	1898-99	1900
	(Definite)	(Minimum)	(Minimum)
8-inch B.L.R.	6000 yds.	7200 yds.	6100 yds.
10-inch B.L.R.	7000 "	7900 "	6600 "

	1897 (Definite)	1898-99 (Minimum)	1900 (Minimum)
12-inch B.L.R.	8000 yds.	8500 yds.	7000 yds.
12-inch Mortar	6000 "	5100 " to 9000 "	4500 " to 8000 "

The annual allowance of ammunition was as follows:

8-inch M.L. rifle	10
8-inch B.L. rifle	3
10-inch B.L. rifle	3
12-inch B.L. rifle	3
12-inch B.L. mortar	3
15-inch S.B. gun	8
10-inch S.B. gun	10

Relative to whether practice should be at fixed or moving targets, General Orders No. 41 prescribed: "Whenever practicable, practice at moving targets will be had as soon as reasonable proficiency has been shown with fixed targets." The records indicate that the only two occasions of practice at moving targets under that prescript were at Fort Caswell, N.C.—with 8-inch rifles in August, and with 4.7-inch R.F. guns in September, 1900. On both occassions the target, instead of being towed, moved under sail. It consisted of a "catamaran made of barrels rigged with large square sail and long trailing rudder to keep it before the wind" and had a speed of from three to four miles per hour.

That target practice was still regarded more as a practical lesson in ballistics than as an exercise in gunnery, appears from several provisions of the order—notably, the requirement that observers at base ends and "gunnery specialists" be taken, when practicable, from batteries other than the one firing," so that all officers and men of the battery firing will be present [at the guns] during practice."

Because of the lack of appreciation of the relationship necessarily existing between all the shots of a series fired as a gunnery exercise which such requirements suggest, the ballistic character of the practice is further indicated by the requirements that the small number of shots allowed be fired *pro rata* by the noncommissioned officers of the company, and that the time score of the series be obtained from the sum of the times for the separate shots, counted from "load" to discharge.

For the purpose of determining the merit of the performance, the target for direct fire was a hypothetical vertical plane, 210 feet long and 35 feet high, perpendicular to the line of fire. From top to bottom it was divided into three horizontal belts: 10 feet at the top representing deck; 20 feet in the middle representing freeboard; and 5 feet at the bottom representing vulnerable underwater body. From end to end it was divided into eleven vertical zones, a central zone of 6 feet width being symmetrically disposed about the center with five zones extending from it in both directions, of widths as follows: 9, 15, 21, 27, and 30 feet. Hits in the areas of intersection of the central horizontal belt with the six vertical zones from the center outward, counted 10, 8, 6, 4, 2, and 1, respectively; of the upper belt, 75 per cent of the values for the central belt; and of the lower belt, 50 per cent of the values for the central.

The target for indirect fire was an hypothetical rectangle whose center was represented by the visual target, whose longer axis, in prolongation of the line of fire, was 100 yards, and whose shorter axis was 20 yards. The rectangle was considered as divided into a central rectangle and five surrounding zones of exterior dimensions as follows:

			value
40 yds.	x	4 yds.	10
44 "	x	6 "	8
55 "	x	9 "	6
70 "	x	12 "	4
90 "	x	16 "	2
100 "	x	20 "	1

Considered as a means of inculcating the principles of gunnery, the change in the method of determining the merit of the performance, from the mean absolute deviation to the number of "hits" upon given areas, was a distinct retrogression, though the method did retain a certain connection with the mean absolute deviation through the relative values assigned those areas.

The sidelight to be gotten upon the development of gunnery from a consideration of the subject as taught the enlisted force, indicates progress, in that to the list of subjects published in General Orders No. 132 of 1890, and with only slight modification repeated in General Orders No. 141 of 1895, was added the use of range tables.

General Orders No. 41 of 1896 remained in force till

March 19, 1901, except in so far as the allowance of ammunition and the hypothetical target were concerned. By General Orders No. 18 of 1897 two of the three charges allowed for practice with the B.L. rifles were made reduced charges, leaving only one full service charge to be fired annually; and by General Orders No. 129 of 1899 the service had foisted upon it the firing of rebanded Parrott projectiles. Both of these amendments indicate that, in the minds of those then governing it, coast artillery target practice was not an exercise in gunnery, or the regulation of fire, but merely an opportunity to explode a charge of powder in a gun containing a projectile—one step in advance of firing with blank charges in the process of familiarizing the personnel with its matériel.

The hypothetical target was changed by the Drill Regulations of 1898, in which use was made of an hypothetical battleship 360 ft. x 72 ft. x 15 ft., considered both "end on" and broadside, the number of hits on the two positions being divided by 2. For diagrams of the target see Plate XX of the 1898 Drill Regulations, and for an exposition in full of the method of estimating hits see pages 130 and 131 of those drill regulations; here will be remarked merely that the center of the water line of the visual target represented the point where the plane of the water level was pierced by the intersection of two vertical planes containing, respectively, the center lines of beam and length of the hypothetical battleship. From the point of view of relationship of target practice regulations to rules of gunnery, that, of course, was a mistake; for there being no way in which an observer using a depression position finder or a gun pointer using a telescopic sight can direct his telescope upon such intersection, the water line of the visual target should always represent the water line of a battleship; and the actual point upon which the gun is laid, when it is other than the ship's waterline, should be provided for in a constant correction, which then becomes a part of the system of gunnery.

The change from the hypothetical area of General Orders No. 41 of 1896 in which some relation to the mean absolute deviation was still retained through the values assigned different sections, to an hypothetical battleship on which hits counted equally, irrespective alike of the battleship's position, broadside or end-on, and of their location upon the ship's surface, was a still further retrogression, when considered from the point of view of the basic principle of gunnery.

The year 1901, in the history of gunnery in the United States, is such an one as, from time to time, is observed in the development of all arts and sciences: it is characterised by the coming into flower of plants that must have been watered through many preceding years.

By the reorganization act of February 2nd the artillery acquired a Chief to direct the future development of its gunnery and young battery commanders to aid him. By the same act a direct aid to the development of gunnery was given in the extra pay allowed enlisted men who qualified as gunners—two dollars to first class and one dollar to second class.

The year 1901 saw also the first target practice and instruction order issued subsequent to the Drill Regulations of 1898. This was General Orders No. 36 of March 19th, and it marked many advances.

General Orders No. 36 prescribed that in one season one company should have practice with one caliber of breech-loading rifle of 8-inch or greater caliber, or with the 12-inch breech loading mortar, and with rapid fire guns. Where the 8-inch converted muzzle loading rifle was available, there was to be additional practice with it also.

The day of specialization had not arrived; in fact, it was the desire to instruct all organizations in the use of as many different classes of ordnance as might be practicable; so one company might have practice with: (1) 8, 10, or 12-inch B.L. gun or 12-inch mortar; (2) 6 or 15-pdr. R.F. gun; (3) 4, 4.7, 5, or 6-inch R.F. gun; and (4) 8-inch converted muzzle loading rifle. The only loss of opportunity for variety observable, is in the classing of the 12-inch mortar with the 8 to 12-inch rifles.

In the ammunition allowance, while, for 8-inch, 10-inch, and 12-inch rifles, reduced, or practice, charges were continued, yet the proportion of service charges was increased, there being five practice and five service charges. For all guns from 4 to 12-inches in caliber, and for the mortar, the number of shots allowed was ten. For the 6-pdr. and 15-pdr. the allowance was twenty.

Subcaliber practice was introduced and the allowance was fixed at 300 for guns above 6 inches in caliber; 1000 for guns from 4 to 6 inches, inclusive; and 2000 for the 6 and 15-pounders.

All practice was to be, so far as practicable, with smokeless powder; and, without qualification, it was prescribed that all practice should be at moving targets.

Inevitably, with the inauguration of practice at moving

targets, in the regulations for target practice had to be included rules that would virtually constitute a system of gunnery. Hitherto all practice had been at fixed targets and practically without time limit; now it was to be at a moving target, which fact of itself naturally introduced the element of time. The problem was to destroy a moving target before it could get away.

The time element was provided for by allowing four minutes between shots from the 12-inch B.L.R. and 8-inch M.L.R.; two minutes, from the 8 and 10-inch B.L. rifles; and five minutes, from the 12-inch B.L. mortar; and by allowing for the rapid fire guns rates of fire as follows: 6-inch, one shot a minute; 5, 4.7, and 4-inch, two shots a minute; and 15 and 6-pdrs., three shots a minute.

For enabling the battery commander to destroy the target he was given its location every thirty seconds, for all calibers; was allowed five minutes between the first and second and second and third shots with big guns (between the first and second with rapid fire guns); and was given the plotting of the first two shots with the big guns and the mortars (of the first shot only with rapid fire guns).

While the term *trial shot* was not introduced at this time, yet we see that what the trial shot represents in a system of gunnery was introduced in the time allowed between the first and second and second and third shots and in the plotting of those shots. Indeed, the purpose served by trial shots was doubly recognized; for General Orders No. 36 prescribed that, immediately before the practice, each post commander should cause to be tested each kind of powder to be used, and for the purpose made provision for ballistic machines and five charges of each kind of powder.

For determining the merit of practice, the hypothetical target of the 1898 Drill Regulations was continued in use.

While, as we have already seen, General Orders No. 36 did, in fact, adopt as a rule of gunnery the preliminary determination of a working center of impact, yet we observe that Remark *a* on Form 31 provided for correction as a result of observation of fire also. So it is interesting to learn from another source just what was, at that time, the opinion of the best artillerists of the service on the relative merits, for incorporation in a system of gunnery, of the two means of regulating fire—trial shots and observation of fire.

We learn that opinion from correspondence in which one

able artillerist who had had no part in the formulation of General Orders No. 36 wrote to one who had and objected to the battery commander's being furnished the plotting of his first two shots. The latter replied:

> I am, and I think others here are, in entire sympathy with you in your position * * * * that the B.C. should be given absolutely no information except what he himself can pick up from his B.C. table and the observed result of his firing. * * * * It was thought, however, by some of the board that in *beginning* the system of firing at moving targets, it would be better *for a time* to take an intermediate position, to give officers the data in the old way for the first two shots. It was assumed and hoped that, later, no information would be given.

However that may be, it is clear that the formulators of General Orders No. 36 recognized trial shots as a present necessity, even if they did hope they would not prove a future one; and they very wisely provided for them, thereby adding another to the already numerous advance steps in gunnery in the United States made by General Orders No. 36.

In General Orders No. 97 of August 25, 1902, were introduced many new features in the circumstances of practice, such as: holding practice three times a year in different quarters for guns, and twice a year for mortars; limiting the practice by one company to one class of rapid fire gun in addition to the practice with large gun or mortar; prescribing that the time for holding practice should not be communicated to the personnel more than one day prior to its commencement; etc.

In connection with distributing the practice through three quarters of the year, there was an increase in the allowance of ammunition; for a series for any one occasion for large guns and mortars was five shots and for rapid fire guns ten shots.

The disposition not to allow trial shots which we have already seen reflected in the correspondence quoted concerning General Orders No. 36 of 1901, was manifest in General Orders No. 97 of 1902 in the ommission of provision for testing the powder before practice, for furnishing the battery commander the plottings of his first two shots, and consequently, of course, for increased time between the first and second and second and third shots. In the system of gunnery employed in 1902, therefore, fire was regulated wholly by observation of fire.

The times allowed between shots for mortars was reduced from five to four minutes, and for 12-inch rifles, from four to three. The time allowances for rapid fire guns also were reduced: 6-inch, three shots a minute; 5, 4.7, and 4-inch, four shots a minute; and 15 and 6-pounders, five shots a minute.

The estimation of hits remained as prescribed in the Drill Regulations of 1898.

In the instruction of gunners, to the requirements already quoted from General Orders No. 41 of 1896, there had been added by General Orders No. 36 of 1901, more detailed information relative to sights, quadrants, etc., and information relative to difference charts and range scales; and now by General Orders No. 97 of 1902 detailed instruction in the use of thermometers, barometers, anemometers, and wind vanes, and in the determination of wind components, was required.

At about this time there were being carried on at Fort Monroe, experiments that were destined to have a very material effect upon our system of gunnery. On May 3, 1902, Captain E. M. Weaver, Artillery Corps, an instructor in the Artillery School, addressed to the adjutant of Fort Monroe a letter in which he requested that arrangements be made for testing experimentally the principles involved in a Battery Manning Drill of which he submitted a copy. In his letter, Captain Weaver enumerated five objects as intended to be accomplished by the drill, and of the five we shall quote here the fourth and fifth as being especially pertinent to the study of the development of gunnery in which we are now engaged.

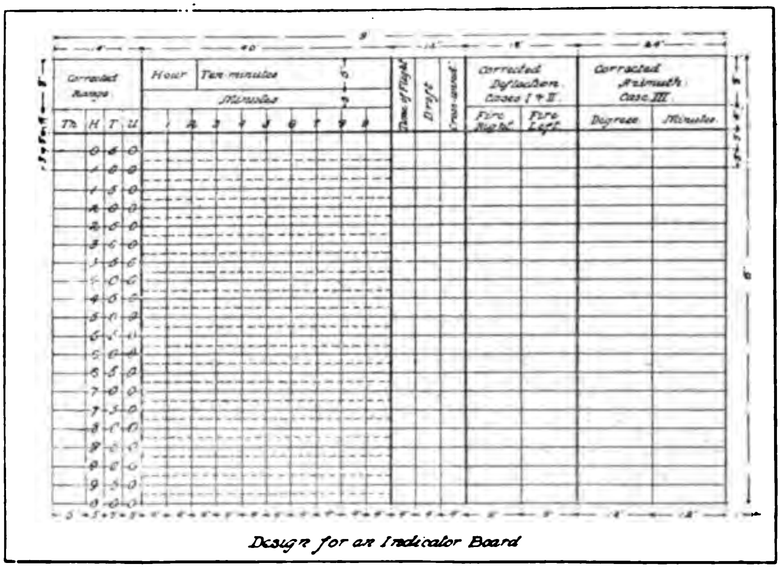
4. A method of "following" a moving target is submitted which, it is believed, will give much greater rapidity of fire at moving targets than has been attainable under the method of the Drill Regulations, with at least as great a degree of accuracy as is given by that method.

5. The design of *an indicator board for corrected range and corrected azimuth* is submitted, which, together with a "*present time*" *indicator*, places before those at the guns *continuously* the *range* corrected for atmospheric conditions, variations of muzzle velocity, tide, wind along range and travel during time of flight, and the *deflection* corrected for drift, wind across range, travel during time of flight, so that the gunner or gun commander may at any instant know what the *corrected* range-deflection conditions are, and it represents *graphically* the *rate of change* of range for the time immediately before and after the "present time." These combinations are believed to present to those charged with aiming or laying coast guns, that is the gunner, traversing and elevating numbers, simpler duties than have obtained heretofore, thus making unnecessary so high a standard of drill and instruction as is now required for satisfactory practice. This last is thought to have an important bearing on efficiency in time of war, when it will be impossible to man all of our guns with highly trained cannoneers. No special instruments or apparatus are required, or allotment of funds.

It was about this time also that occurred the discussion of the relative merits of Cases II and III, the history of which will be found in Captain Morse's article on *Evolution of Our*

System of Fire Control, published in the JOURNAL for March-April, 1913.

In the summer of 1902 there were held, in and about the waters of Long Island Sound, joint coast artillery and navy maneuvers, of which the effect upon coast artillery gunnery, though not directly traceable, yet must have been great; for it was the first occasion on which the coast artillery had an opportunity to practice its methods upon a number of moving targets in one locality.



CAPTAIN WEAVER'S INDICATOR BOARD OF 1892 1529

The year 1902 was further distinguished by the appointment, in Special Orders No. 260, of November 5, of a board of officers to revise the Drill Regulations for Coast Artillery. The personnel of the board comprised Colonel John P. Story, Major John A. Lundeen, Major Garland N. Whistler, Captain Erasmus M. Weaver, and Captain George T. Bartlett. With changes in its personnel, the board continued its labors for several years, issuing from time to time provisional regulations in pamphlet form from the press of the Artillery School.

Of those pamphlets the one with which this study is most concerned is entitled *Manual for Coast Artillery, United States Army, Part I, Gunnery*. It is a most excellent treatise of the subject, and includes fundamental definitions, a discussion of the trajectory, the ballistic coefficient, deviation,

recoil, accuracy, center of impact, correction of fire, trial shots, and firing at a moving target. Concerning all, sound principles are set forth. Articles 20 to 24 on correction of fire, trial shots, and firing at a moving target, are especially worthy of frequent study by all artillerists, familiarity with the principles there set forth being necessary to prevent our being misled by fallacies in apparent contradiction thereto.

It is interesting to note that, while, year after year since the issue of the 1898 Drill Regulations, the figure of merit has been based on the number of "hits" made on a prescribed area, irrespective of mean absolute deviation, in paragraph 12, page 33, of the pamphiet *Gunnery*, is stated, "*Accuracy of practice* is measured by the distance of the center of impact from the center of the target;" and in paragraph 17, on page 41, "The most satisfactory figure of merit for comparing the target practice of different batteries is the mean absolute deviation from the target."

In General Orders No. 100 of 1903 the term *trial shot* was first introduced, one being allowed on the day of practice on each of the three occasions of practice with 12-inch mortars and guns of caliber greater than six inches. The trial shot was not considered in determining the total score of hits, but was one of the series of five shots allowed for one occasion of practice with all pieces except the 15-pounder and the 6-pounder. Remark *a* on Form 31 shows that correction from observation of fire was permitted.

General Orders No. 100 of 1903 was the first artillery target practice order from which was omitted all mention of the old muzzle-loading armament, General Orders No. 97 of 1902 having provided for "additional practice" with the 8-inch converted muzzle loading rifle. It also marked the growth of specialization by assignment of companies to certain calibers and by provision for permanent gun commanders.

The time prior to target practice at which notification could be given to the personnel was extended to forty-eight hours.

The ranges for the big guns and for the mortars were classified as long (over 7500 yds.), mid (7500-4000), and short (4500-3000); and it was prescribed that the three practices should be held at those respective ranges. The prescribed ranges for practice with rapid fire guns from four to six inches in caliber were from 2000 to 4000 yards; and for 6-pdrs. and 15-pdrs. 1000 to 2500.

Practice with all guns below the 8-inch was held twice a year.

Instead of allowing a certain time between the shots of a series, total time allowances for the several calibers were as follows:

12-inch mortar, 4 shots	16 m.
12-inch gun, on barbette carriage, 4 shots	16 m.
12-inch gun on disappearing carriage, 4 shots	12 m.
10-inch gun on disappearing carriage, 4 shots	10 m.
8-inch gun on either carriage, 4 shots	8 m.
6-inch R.F. gun, 5 shots	2½ m.
5, 4.7, and 4-inch guns, 5 shots	2 m.
6-pdr. and 15-pdr., 10 shots	1½ m.

Effort to train the personnel to an effective use of the qualities of its armament was made by attaching a penalty to tripping a gun on a disappearing carriage more than thirty seconds in advance of the time of firing.

The order contained provisions of which the intent was to determine the error of prediction.

An hypothetical ship was retained as the target for guns of 4-inch and greater caliber; but, as compared with the target prescribed in the 1898 Drill Regulations, conditions were improved by causing the water line of the visual target to represent the water line of the ship, when depression position finders were used, leaving the visual target to represent a point of the median line of the ship only when horizontal base position finders were used. The difficulty for the gun-pointer in Case I, however, still remained.

For mortars, a circular target was introduced for the estimation of hits, the radius being sixty yards; while for the 15-pdr. and 6-pdr. rapid fire guns the material target made its first appearance in our coast artillery service. Its dimensions were 20 feet in length by 5 feet in height.

It is worthy of note that in the case of mortars, at least, some deference was paid the mean absolute deviation as a criterion of accuracy of practice, by giving "hits" in a circle of forty yards radius the value of unity, and hits in the zone included between the two circles of forty and sixty yards radii respectively, a value of only 0.2.

The instruction and examination of gunners was made to include identification of powders, fuses, and primers, action of the last named, and identification of war-ships. The test in

meteorology was reduced to determination of wind components.

In 1903 and the early part of 1904 there took place very interesting correspondence* initiated by Captain C. C. Hearn, Artillery Corps, Commanding the 118th Company of Coast Artillery, between the Coast Artillery authorities and the Ordnance Department concerning the law relating the velocity of the projectile to the temperature of the powder at the instant of explosion. As a result of that correspondence the temperature of test is now published in connection with the velocity attained at test, and the service has been furnished a formula for use in determining, from a comparison of temperatures, the velocity to be expected on an occasion of practice.

Two minor features of the correspondence related to the usefulness of a T, or cross-bow, in determining overs and shorts of trial shots by observation from a boat in the vicinity of the target; and the necessity for removing the slushing material from the bore of a piece before firing the first shot, since the presence of the slushing material had been observed to reduce the velocity.

General Orders No. 141, of August 27th, 1904, is remarkable not so much for advance in methods of gunnery used in target practice as for detailed methods of daily or weekly instruction in gunnery. General Orders No. 100 of 1903 had made provision for a monthly test in rapidity of serving ammunition, and in loading and firing, introducing an element of competition by requiring the times to be published to the command; and now General Orders No. 141 of 1904 prescribed a weekly test in the accuracy of sighting rapid-fire guns and in the accuracy of laying big guns and mortars for direction by Case III.

Except for some changes in detail, the conditions of target practice prescribed in General Orders No. 141 were, especially in the case of guns, about the same as those in General Orders No. 100 of 1903. The limit of notification of practice was made twenty-four hours again, instead of forty-eight; the practice in the three quarters was to be in three different range belts for large guns and mortars, for the guns the belts being 4000 to 7000 yards, 5000 to 8000, and 6000 to 9000, and for the mortars 1st to 4th zones inclusive, 5th to 7th, and 8th to 10th; and the times allowed for firing a series of four shots from the large guns were reduced by four minutes each, the time for the 12-inch gun on barbette mount becoming twelve

* See *Artillery Memoranda No. 2*, Artillery School Press, 1904.

minutes, for the 12-inch on disappearing eight minutes, for the 10-inch on disappearing six minutes, and for the 8-inch on either mount four minutes.

In the case of mortars, one decided step in advance was taken in allowing three trial shots to be fired on the day of practice on each of the three occasions of practice; and the order of fire of mortars was radically changed, but not for the better, by requiring simulated pit-salvos—all four mortars in a pit being loaded and laid parallel on data for one prediction and fired at intervals of ten seconds, to enable each splash to be separately observed and plotted.

In the hypothetical target prescribed in General Orders No. 141 of 1904 return was made to the practice of having the visual target represent the mid point of the ship's axis for both H.P.F. and D.P.F. For purposes of scoring hits with guns, the full danger space for a ship, 145 yds. x 25 yds. x 8 yds., was allowed beyond the target, and half the danger space short of the target. For mortars, each hit on the deck of the hypothetical ship was scored. The material target for rapid fire guns was made 6 feet by 24 feet, instead of 5 x 20.

Form 819 shows that correction from observation of fire was permitted.

In General Orders No. 101 of 1904 provision was made for fire command subcaliber practice and subcaliber night firing.

Under the provisions of General Orders No. 93, of June 17th, 1905, target practice, instead of being three times a year for large guns and mortars, and twice a year for rapid fire guns, was held twice a year for all guns. This change was stated in paragraph 36 of the order to be on account of the limited allowance of ammunition; and accordingly, for the guns, the number of record shots on each of the two occasions of practice remained four, as it had been before on each of the three occasions of practice. For the mortars, however, a slight increase in the total amount of ammunition allowed for record shots for the year resulted, the total for two occasions being thirty-two shots, whereas in 1904 it had been twenty-four for three occasions. For trial shots from guns of 6-inch caliber and above, three were allowed, all being fired on the day of the first occasion of practice; for mortars three trial shots were allowed for each occasion of practice. The two occasions of practice were separated by at least four months.

Trial shots were fired at fixed visual targets, and were observed from both tug and shore.

Mortar record practice was conducted by actual pit-salvos.

For rapid fire guns the range was given before the opening of fire, and as often as practicable afterwards.

Correction from observation of fire was still allowed.

The time allowed for a gun on disappearing carriage to be in battery before firing was reduced from thirty to twenty seconds.

Instead of a total time allowance for the series of shots, in General Orders No. 93 an allowance was made for each shot as follows:

Mortar, pit-volley	3 minutes.
12-inch gun on B.C.	3 minutes.
12-inch gun on D.C.	2 minutes.
10-inch gun on B.C.	3 minutes.
10-inch gun on D.C.	1½ minutes.
8-inch gun on B.C.	2 minutes.
8-inch gun on D.C.	1½ minutes.
6-inch gun on pedestal	30 seconds.
6-inch gun on D.C.	30 seconds.
5-inch—15-pdr	20 seconds.

The ranges for practice were fixed as follows:

15-pdr.	800-1500 yds.
4-inch to 5-inch	2000-4000 yds.
6-inch	3000-5000 yds.
8-inch to 12-inch	5000-7000 yds.
Steel mortars	6th-9th zone.
C.I. mortars	4th-8th zone.

General Orders No. 93 of 1905 is noteworthy because of its containing in paragraph 44 the first formal announcement of the adoption of a policy of specialization in the instruction of companies, it being distinctly stated that the assignment of companies to batteries, and therefore to calibers, would not be changed from year to year.

In General Orders No. 122 of 1905 were first published to the service powder test tables, including the temperatures of the atmosphere and the powder charge at the time of test. This was a step forward in the development of accurate gunnery.

From shortly after the appointment of the board of officers on revision of drill regulations near the close of 1902, till 1905, there appeared from time to time, as has been noted already, pamphlets publishing to the service the results of the

board's labors; and now in 1906 so much of these pamphlets as had to do with general principles, the service of the piece, and the service of other material, except that included in the position-finder service, was issued from the War Department as Provisional Drill Regulations. (Provisional regulations for the position-finder service had been issued in pamphlet form from the Artillery School Press in 1905.)

But, while the publication of the Provisional Regulations had, in the general sense, an effect on the development of coast artillery gunnery wholly disproportionate to the passing comment upon them made here, yet because of the particular point of view from which the present study is being made, that comment is restricted to noting the advantages to our gunnery that have resulted from the method prescribed in "Routine Duties" for simulating one day each week fire by Case II.

As compared with the target practice regulations for 1905, those for 1906, published in General Orders No. 155 of September 13, 1906, are noteworthy for the following changes: the allowance for guns of 6-inch caliber and above, as well as for mortars, of three trial shots on each of the two occasions of practice, the trial shots being fired on the day of the firing of the record shots; the allowance of three ranging shots, fired immediately before the record shots, for rapid-fire guns below 6-inch caliber; the communication to rapid-fire batteries of the range before "Commence firing" and after each authorized interruption only, instead of as often as practicable; the adoption of the 10 ft. x 24 ft. material target for R.F. guns below 3-inch; the extension of the superior limit of the permissible practice ranges for guns of major caliber from 7000 to 7500 yards; the increase in the number of record shots for each occasion of practice with major caliber guns from four to five; the adoption for mortars of an hypothetical target consisting of a circle of 100 yards diameter; the change in the order of fire with mortars from pit-salvos to single shots; the allowance for one shot with mortars of two minutes in the case of the 1896 carriage and of four minutes in the case of the 1891 carriage; and the change in the time limit of notification of practice from twenty-four hours to forty-eight, as in 1903.

In General Orders No. 83 of 1907 was announced a policy of close relationship between the Coast Artillery and the Navy, pursuant to which arrangements were made for members of the Coast Artillery Corps to witness target practice aboard ship. This undoubtedly has had a broadening influence upon

our methods which in general has been beneficial, though the adoption for a time of the material target for guns of major caliber is believed to have been unfortunate.

The act of Congress approved January 25th, 1907, whereby extra pay was allowed observers, gun commanders, and gun pointers stimulated interest, and unquestionably had an important influence in the development of gunnery. Here, however, as elsewhere in the history of our gunnery, even with ready access to the reports of practice for the different years, one would be confronted with great difficulty in an attempt to measure improvement by a comparison of those reports; for the method of valuing the results of practice has varied almost from year to year. But more of this later, when, having completed our review of the twenty years, we may look back and compare the various methods.

The regulations for 1907 were published in General Orders No. 105 of May 11th, 1907, in which the principal innovations were: prescribing Morris-tube practice in coast artillery instruction (this, however, never got further than the order, as no tubes were ever issued to the service); including fire command practice in service practice; requiring the three ranging shots for guns below 6-inch caliber to be fired at the record practice moving target; prescribing only minimum ranges, instead of minimum and maximum limits; *permitting* the blending or airing of powder; and introducing a figure of efficiency in which entered hits per gun per minute and the probability of hitting.

While General Orders No. 105 left the time limit of notification of practice at forty-eight hours, the limit was changed to one week by General Orders No. 192.

The changes introduced in General Orders No. 106 of June 26, 1908, publishing target practice regulations were: battle command and emergency subcaliber practice; blending of powder *required;* allowance of nine trial shots before each of the two occasions of practice with mortars; reduction to ten seconds of the time allowed a gun on disappearing mount to be in battery before firing; and, for guns of 6-inch caliber and above, abandonment of the hypothetical ship as target, and adoption of a 30 ft. x 60 ft. hypothetical target.

By act of Congress approved May 11th, 1908, the extra pay allowed gunners was increased to three dollars for first class and to two for second class.

In the regulations for 1909, published in Coast Artillery Memorandum No. 1 of February 17th of that year, the new

features were: battle command service practice; four trial shots for mortars; three trial shots allowed for 4.7-inch and 5-inch guns; advancement from short range on the first occasion of practice to long range on the second made dependent upon the attainment of a certain figure of merit; and a material target, 30 ft. x 60 ft. for guns above 4-inch caliber.

The year 1909 is marked not only by the publication of the 1909 Drill Regulations, but also by the appearance of Coast Artillery Memorandum No. 6 of August 5th, in which was presented to the service sixty pages of notes concerning "Preparation for and Conduct of Seacoast Artillery Target Practice."

From the introductory remarks of that memorandum is quoted the following, as pertinent to the history of the development of our gunnery:

> Coast artillery development has been so rapid since modern guns and carriages have been in use that we have not had time to take up the problem of gun fire with the care which it merits; speed has in a great many cases preceded accuracy. Many of the numerous details which require attention in practice have been overlooked. Recently, however, individual officers have been going into the problem more, and the next few years should see great improvement in gunnery.

And, as a statement of the target practice problem, the following extract is quoted:

> The final objective of target practice is to develop ability to *hit*. To hit, or to throw the projectile accurately in practice or in service, we must have, for successive shots, uniformity in the several factors that enter into the problem of gun fire, viz.:
>
> 1. Gun and carriage (action of).
> 2. Projectile.
> 3. Powder.
> 4. Position finding service (operation of).
> 5. Personnel (work of).
>
> The target practice problem, then, reduces itself to an elimination of the variants affecting these factors.

From the point of view of the present study, it is seen that an analysis of the problem should set forth a sixth item, which, in the analysis quoted, is included in "(5) Personnel (work of)"; and that is, the system of gunnery, or a codification of the general rules and regulations governing our gunnery that should be removed from the province of individual judgment as to their desirability. But, though the memorandum did not specify this item in the analysis, yet, as will appear later from further quotations, the memorandum did enunciate several of the general rules.

Before leaving the analysis of the target practice problem, it will be remarked that the analysis given in Memorandum No. 6 of 1909 would, perhaps, have been more helpful had it coordinated the items specified. For instance, the first three items are clearly elements of the general subdivision, matériel, while the fifth item is the general subdivision, personnel, and the fourth a combination of matériel and personnel. From the point of view of the present study the analysis would be

- (1) Matériel
  - (a) Gun and carriage.
  - (b) Fire control apparatus.
  - (c) Ammunition.
- (2) Personnel
  - (a) Gun section.
  - (b) Fire control section.
- (3) System
  - (a) Fundamental principle.
  - (b) Standard of excellence.
  - (c) Means of applying the principle and attaining the standard.
    - (i) Corrections to be applied alike in practice and service to compensate for difference between apparent and true. (For instance, sighting point and point it is desired to hit);
    - (ii) Rules governing opening fire, or initial shots;
    - (iii) Correction of fire, etc.;
    - (iv) Records.

It is obvious, of course, that in the analysis indicated, only the merest outline of "(3) (c) Means, etc.," has been attempted, and that for the purpose of illustration alone; an exhaustive treatment of (3) (c) could follow only upon enunciation of (3) (a) and (b)—principle and standard.

After a very helpful and detailed treatment of the matters to be considered in adjustment of matériel, there follow interesting discussions of many subjects more or less directly connected with the fundamental principles of gunnery. Among these, under "Accuracy of Fire and Practice," it is interesting to note the statement that "accuracy of practice is determined by the distance of the center of impact from the center of the target," thereby emphasizing the anomalous position our service has taken in this matter since General Orders No. 108, 1888, ceased to govern—constantly recognizing in words one standard of accuracy while applying in practice a totally different one.

In Coast Artillery Memorandum No. 6, was suggested means of meeting the requirements of the rule of gunnery for our service introduced in General Orders No. 141 of 1904, by the prescription that the hypothetical target extended from

a line half the danger space short of the visual target to another line the full danger space beyond the visual target. The means consisted of making a correction for tide, + 7½ feet, which was one-fourth the height of the vertical target, 30 feet, and would therefore result in placing the expected point of impact one-fourth the danger space beyond the visual target. This is a good example of the kind of correction referred to under (3) (c) (i) of the analysis outlined on page 278.

What has previously been said relative to the intimate relationship between target practice regulations and rules of gunnery, is also aptly illustrated by the regulation which placed the center of the hypothetical target one-fourth the danger space beyond the visual target; for, while that regulation existed, the method indicated in the Memorandum No. 6 for meeting it constituted a rule of gunnery, and when in paragraph 131 of the Regulations for 1913 the extent of the hypothetical target short of the visual target was changed from one-half the danger space to ten yards, a corresponding change was made in a rule of gunnery. They are matters such as this that must be codified in the system and not left to individual judgment of members of the personnel: if half the danger space or ten yards short of the target is determined upon as a proper provision for effective ricochet hits, means for making that provision in practice must be included in the rules of gunnery. It is presumed that the reduction of the hypothetical target zone to ten yards short of the target was based on the doubt expressed in Coast Artillery Memorandum No. 8 of 1910 as to whether shots which strike one-half the danger space short of the target will make hits.

The foregoing suggests as a legitimate use for a material target in connection with practice of coast defense guns of large caliber, experimental determination of the point on or in the vicinity of a ship upon which to lay in order to have the greatest probability of making effective hits.

Relative to correction from observation of fire during the firing of the record shots, Coast Artillery Memorandum No. 6 of 1909 made reference to a memorandum dated June 1, 1908, from the office of the Chief of Coast Artillery, in which the conclusion had been indicated that corrections based on observation of fire were inadvisable in the case of batteries equipped with separate position finding systems; viz.: 8-inch, 10-inch and 12-inch rifle batteries, and the more important 6-inch rifle batteries, because observations of overs and shorts had

been found unreliable. The Chief of Coast Artillery had expressed the opinion that it was not advisable to apply such corrections till a number of shots, not less than three, had shown a constant error:

> Observation of fire is a means of correcting errors in position-finding service or the manipulation of the guns, and to employ it intelligently we must assume that the errors we are correcting for are constant.

In harmony with the view of correction from observation of fire manifested in the memorandum just cited, we find in paragraph 48 of Coast Artillery Memorandum No. 11 of 1910, the requirement that no correction shall be based on fewer than three shots, and in paragraph 56 of the Regulations for 1912 the extension of that requirement to the effect that no correction shall be based on fewer than three shots all over or three shots all short. In the regulations for target practice issued since those of 1912, correction from observation of fire has been wholly prohibited in the case of the major caliber pieces.

Amongst other subjects discussed in Memorandum No. 6 were calibration firing, probable error cards, the effect of difference in weight of projectiles, and the advantages of blending powder. Relative to the latter was cited the case of one lot of powder of which, while two charges slightly under normal weight and two charges slightly over normal weight, all *unblended*, gave variations respectively of 53 and 49 f.s. in initial velocity, five charges, *blended*, gave a variation of only 17 f.s.

A beginning of the custom of analyzing reports of practice is discernible in Coast Artillery Memorandum No. 6, of 1909.

In Coast Artillery Memorandum No. 1 of January 1, 1910, provision was made for night practice with 3-inch guns, and for the presence at all service practice of an umpire representing authority higher than that of the commander of the coast artillery district, or coast defense command, as it would now be called. Three trial shots were allowed for guns of all calibers, and trial shots for both guns and mortars were required to be fired on the day of practice.

Coast Artillery Memorandum No. 11 of December 30, 1910, prescribing regulations for 1911, allowed four trial shots for all guns and for mortars, and required those for guns to be fired at least twenty-four hours before the first day of practice, the interval between the two occasions of practice for one battery being not more than one week, nor less than twenty-

four hours. The trial shots for mortars were required to be fired on the day of practice.

"Regulations for the Instruction and Target Practice of Coast Artillery Troops, 1912" (January 3rd), included the following features: emergency firing at service practice; "compound" blending, or mixing of different lots of powder; a more positive requirement of battle command practice; no trial shots for guns below 5-inch caliber; and one set of trial shots for two or more companies making use of the same lot of powder. The target for major caliber guns was still the material target, 30 ft. x 60 ft.

The regulations for 1913 are conspicuous for the introduction of night firing with major caliber guns and with mortars; for the requirement that guns shall be laid for deflection upon data furnished by the deflection board only; for the requirement that trial shots be fired, not at a fixed target and observed from a tug, but at a point and observed from the shore; and for a return to a hypothetical record target for guns of major caliber.

The hypothetical target prescribed consisted of a parallelogram the longer median line of which coincided with the "line of direction" and extended from the visual target ten yards in the direction of the guns and the danger space in the opposite direction, the other median line of the parallelogram coinciding with the course of the visual target and being twenty yards in length.

Into the figure of merit for 1913 was introduced a term which allowed a certain weight to the approximation of the center of impact to the target; but the value of that term was limited to 25, while the maximum value of the term into which "hits" entered was 75.

The Regulations for 1914 introduce further changes in the record, or hypothetical, targets for both mortars and large guns.

For mortars the target is a rectangle 150 yards by 30 yards, having its longer axis coincident with the track of the target and its center coincident with the mid point of the visual target.

For guns, the target is a parallelogram similar in all respects to the one prescribed in the 1913 regulations, except in the length of its sides. The shorter side, parallel to the course of the target, is thirty yards; while the longer side extends toward the gun twenty-five yards, and away from the

guns the "danger space" plus fifteen yards. A new rule for directing fire upon the center of the hypothetical, or record, target is now required.

In the expression for the figure of merit for 1914 the center of impact term still enters and with the same relative maximum value to the "hit" term, but with a change in form.

From about 1909 to the present date, analysis of the reports of practice has been becoming more prominent in our service, and bids fair to prove a potent factor in future progress in gunnery. In Coast Artillery Memorandum No. 8, of September 15, 1910, was stated:

A frank discussion of errors which are made in practice and reasons for poor practices is in some cases more valuable than good shooting.

The spirit which prompted that statement is absolutely essential to progress: gunnery must be placed on a plane of scientific investigation—every officer alert to learn and not in fear of being proved in the wrong. The art of gunnery is founded upon a scientific principle, and scientific methods must be used to arrive at its truth.

Efforts to arrive at a true system of gunnery, to be successful, must be directed by a continuing policy: no method which it is not desired to have enter the system as a rule of gunnery, should be prescribed as a regulation for target practice; and regulations, once made, should be changed only for purposes of considerable importance. Therefore, as an aid in our future direction, tabulated summaries will be presented of regulations that have governed in the past some of the matters more directly affecting the system of gunnery. Among these are the figure of merit, and the targets, trial shots, and communication of ranges for rapid fire batteries.

The establishment of an appropriate figure of merit is of the greatest importance in the development of gunnery. It is the determining factor in the peace training of the officer's sense of proportion; for what the figure of merit puts a premium upon in target practice, will be rated of first importance in gunnery. Care should be taken, therefore, to have in the expression for the figure of merit no variable that is not directly associated with the principle through the application of which success is to be attained; and, if there be more than one variable, all should be given relative weights according to their value in principle. The figure of merit should be designed so that error will not under any circumstances result in an improvement of the score: there are very many sports in which

"scratches" do not count, and much less should they count in an art so serious as gunnery. The figure of merit should contain no term or factor that would encourage "jockeying" for place; and this is an argument for simplicity and strict adherence to principle; for if the figure of merit be complex and more or less arbitrary in character, "jockeying" will surely creep in. And last, but by no means least, the figure of merit should be constant; for its effect upon the development of gunnery depends in large measure upon the readiness with which it indicates to us whether or not we are progressing from year to year.

From General Orders No. 108 of 1888 to the Regulations for 1914, the changes in the figure of merit, or its equivalent, for not even the phrase itself has remained unchanged, will appear from the summary on pages 285-287.

Upon the system of gunnery to be used for rapid-fire guns, trial shots and the communication of ranges have a direct effect, while the class of target (whether rapid fire or big gun target) has an indirect influence. In the table on pages 284-285 is given a summary of the regulations that have obtained in those matters.

Comparing our coast artillery gunnery today with that of twenty years ago we find moving targets instead of fixed, modern ordnance instead of old fashioned smooth-bore, rapid-fire guns where there were none, telescopic sights instead of open tangent sights,* and an annual allowance of service ammunition that removes target practice from the category of a mere illustrated exercise in ballistics or a step in advance of blank charges in the training of a cannoneer.

In the rounding out of our system of gunnery, however, there is work for us yet. By analysis of results of target practice we must separate errors of personnel from errors of matériel, and also scrutinize the evidence of efficacy or inefficacy of our system; and we must incorporate in the system general rules concerning all the essential matters which experience and study indicate as advisable to be removed from the province of individual judgment, while omitting from the system matters that are unessential in service, as distinguished from practice.

* Discussion of sights and kindred matériel has been omitted from this study because of being included in *Notes on the Progress of Coast Artillery Gunnery in the United States during the Last Twenty Years*, prepared by Captain A. L. Rhoades and to be found immediately following this study.

RAPID-FIRE GUNS: TRIAL SHOTS, TARGETS, AND COMMUNICATION OF RANGES

Year.	Smallest caliber using big gun target.	R.F. target for other calibers.	Smallest caliber allowed trial shots.	Number and character of trial shots.	Ranges communicated.
1901	All calibers.	......	All calibers.	First shot plotted, and five minutes interval before 2nd shot.	Location of target every 30 seconds.
1902	All calibers.	......	......	None.	Position of target at regular intervals not exceeding 30 seconds.
1903	4-inch: vertical target only.	5 ft. x 20 ft.	......	None.	Yes.
1904	4-inch.	6 ft. x 24 ft.	......	None.	Yes.
1905	4-inch.	(Same)	6-inch.	3 on day of first practice.	As often as practicable.
1906	4-inch.	10 ft. x 24 ft.	All calibers.	6-inch allowed 3 trial shots before each practice. Below 6-inch 3 *ranging* shots before each practice.	Before "commence firing" and after each authorized interruption for batteries not equipped with separate position finding service.
1907	6-inch.	(Same)	All calibers.	6-inch allowed 3 trial shots. Below 6-inch allowed 3 *ranging* shots at moving target, in connection with record shots.	(Same)
1908	(Same)	(Same)	(Same)	(Same)	(Same)
1909	4.7-inch.	(Same)	4.7-inch.	3 on day of practice.	(Same)
1910	4-inch.	(Same)	All calibers.	3 on day of practice.	(Same)

1911	(Same)	(Same)	(Same)	4 twenty-four hours before practice.	(Same)
1912	4-inch.	(Same)	5-inch.	4 twenty-four hours before.	Initial ranges for batteries not equipped with separate position finding service.
1913	5-inch.	(Same)	5-inch.	3 on day of practice.	Yes.
1914	(Same)	(Same)	(Same)	(Same)	(Same)

FIGURES OF MERIT AND TARGETS

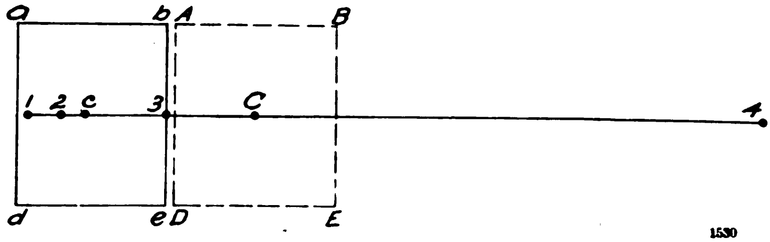
(Figures of merit for guns only are given; those for mortars are the same in principle.)

Year	Figures of Merit.		Record Targets.	
	Phrase	Expression.	Large guns.	Mortars.
G.O. 108, 1888	Figure of merit.	Mean absolute deviation.	A point.	
G.O. 41, 1896	Hits.	Weighted for location in belts and zones of target.	Hypothetical vertical plane, 210 ft. x 35 ft., 3 horizontal belts and 11 vertical zones.	100 yds. x 20 yds. central rectangle and 5 zones.
D.R. 1898	Estimation of hits.	Total number of hits on "end-on" and on "broadside" target, divided by two.	Hypothetical ship, 360 ft. x 72 ft. x 15 ft., "end-on" and "broadside," visual target at center.	Deck of the ship.
1903	Hits.	Number of hits. (Mortars: 40 yds. radius, 1.0; 40-60 yds. zone, 0.2.)	Hypothetical ship, 360 ft. x 72 ft. x 15 ft. visual target at center, for H.P.F. only.	Concentric circles of 60 and 40 yds. radii.

Year.	Figures of Merit.		Record Targets.	
	Phrase.	Expression.	Large guns.	Mortars.
1904	Numerical value of hits.	Number of hits.	Hypothetical ship, 145 yds. x 25 yds. x 8 yds., axis tangent to track, visual target at center, danger space beyond, ½ danger space short.	Deck of the ship.
1905	Score.	Hits $\times$ time factor $-\ \frac{T-t}{T}$ *T* being time allowance, and *t* being excess time.	(Same)	Deck of the ship.
1906	Score.	Hits $\times$ time factor $-\ \frac{T}{T+t}$	Hypothetical ship, 145 yds. x 25 yds. x 8 yds., axis tangent to track for H.P.F. only, D.S. beyond, ½ D.S. short.	Circle, R = 50 yds.
1907	Figure of efficiency.	$\frac{10\,H}{P}$; *H* being hits per gun per minute, and *P* the probability of hitting.	(Same)	(Same)
1908	Figure of merit.	(Same)	Hypothetical vertical rectangle, 60 ft. x 30 ft., D.S. beyond, ½ D.S. short.	(Same)
1909	(Same)	$\frac{CH}{P}$; *C* being a time of loading factor varying with the caliber and mounting.	Material vertical target, 60 ft. x 30 ft.	(Same)
1910	(Same)	(Same)	(Same)	(Same)

1911	(Same)	$\frac{CH}{P} \times \frac{N}{N^1}$; N being the number of hits, and N^1 the number of shots.	(Same)	(Same)
1912	(Same)	(Same)	(Same)	(Same)
1913	(Same)	$\frac{C \times H^2}{Pgtn\ sin^2 B} + \frac{375\ S}{D_1 \times D_2}$ H total number of hits. P probability of hitting. B angle of track with "line of direction" g number of guns. t time of series. n number of shots fired. S length of target in yards in direction of line of fire. D_1 distance of center of impact from center of record target. D_2 mean absolute error of series.	Parallelogram, of which the longer median line coincided with the "line of direction" and extended from the visual target ten yards toward the guns, and the danger space away from the guns, the other side of the parallelogram being parallel to the course of the visual target and twenty yards in length.	(Same)
1914	(Same)	$\frac{C \times H^2}{Pgtn\ sin\ B} + \frac{2500}{D + E}$ D and E being the same as D_1 and D_2 of 1913.	Similar to the above, but having the shorter side 30 yds. and the longer side extending 25 yds. toward the guns, and the danger space plus 15 yds. away from the guns.	Rectangle, 150 yds. x 30 yds., the longer axis being coincident with the track of the target and the center at the mid point of the visual target.

The interesting history of the relative claims to incorporation in our system of moving-target gunnery, at its inception in 1901, of the two methods of approximating the center of impact to the target (trial shots on the one hand and observation of fire on the other), has already been outlined, and we have observed the increasing importance of trial shots and the waning of observation of fire. But simultaneously with this evolution of the trial shot in coast artillery gunnery there has grown up in our Navy a system of "spotting," or observation of fire. And, though it may not be stated that the system is applicable to the coast artillery branch of the service, yet it is suggested as a problem for the future to test observation of fire in our practice for two or three years and by analysis determine whether, on the whole, practice during that time is better or worse therefor. Columns 16, 17, and 18 of the form for analysis facing page 34 of Vol. 40 of the JOURNAL



(July-August, 1913) afford a ready means of such determination. Because of the fact that a system of observation of fire has been developed in the sister service, it would be unnecessary for the Coast Artillery to begin with the seed; a cutting could be obtained.

Another subject for experimental determination is the rejection of so-called erratic trial shots. For not only is the observation of all artillerists in harmony with the statement in the footnote on page 31 of the 1914 Regulations, that "the dispersion of the record shots has been practically the same as the dispersion of the trial shots which furnished the data for those record shots"; but also is the statement justified that, in the same proportion in which an excessive deviation occurs among trial shots, it will occur among record shots fired under like conditions. So there is to be considered the advisability of rejecting, in determining the trial center of impact to be placed upon the record target, certain of the trial shots, because of the more favorable conditions for making hits afforded by the relation of the size of the target to the disperson of the selected

few than by the relation of that size to the dispersion of all. For instance, suppose four trial shots have been fired, their plottings being as indicated at 1, 2, 3, and 4 in the figure.

The distance 1-2 is four yards; the distance 2-3 is thirteen; and the distance 3-4, seventy-four. Then the center of impact of 1, 2, and 3, is at c, seven yards from 1, three yards from 2, and ten yards from 3; and the center of impact of 1, 2, 3, and 4 is at C, twenty-eight yards from 1, twenty-four yards from 2, eleven yards from 3, and sixty-three yards from 4.

Now if the target is twenty yards in the direction 1-4, to place the center of impact C upon the target's center would result in no "hit," while to place the center of impact c upon it would give three "hits"; and since we are to expect in the record shots the same proportion of shots like No. 4 as occurred in the trial shots, by placing c upon this particular target would give a reasonable expectation of 75 per cent of hits out of all shots to be fired.

Our system of gunnery should include, then, a rule that would enable the battery commander, by consideration of the dispersion of the trial shots in relation to the dimensions of his target, to determine "erratic" shots; that is, shots which, for the purpose in hand, should be disregarded.

The foregoing might appear to be an agrument against the approximation of the center of impact to the target and in favor of "hits" as the standard of merit of performance; and so it is, if by center of impact is meant necessarily the center of impact of all shots fired, and by "hits" the number of shots caused to fall upon the target by a reasoned regulation of the center of impact considered. But that would beg the question; for *the standard advocated is intelligent regulation of fire by means of adjustment of the center of impact.*

Just as it would be wrong in principle to use as the figure of merit the approximation to the target of the center of impact of the *splashes*, because of the errors included in them, it would be wrong to use the approximation of a center of impact corresponding to a dispersion that is inappropriate to the target attacked. The measure of success in target practice should be the results obtained through the application of the principles on which gunnery is founded.

Our future development will be in exact proportion to our adherence to principle.

NOTES ON THE PROGRESS OF COAST ARTILLERY GUNNERY IN THE UNITED STATES DURING THE LAST TWENTY YEARS

By Captain ALBERT L. RHOADES, Coast Artillery Corps

The methods of gunnery employed in the Coast Artillery of the United States depend upon the arts of position finding, vessel tracking, predicting, and gun pointing, the type of gun and mount, and the science of ballistics.

The history of the arts of position finding, vessel tracking, and predicting, as practised in our service, were ably presented by Captain H. L. Morse, C. A. C., in an article entitled *The Evolution of Our System of Position Finding and Fire Control,* published in the Journal of the United States Artillery, March-April, 1913, so no reference need be made to them here.

The art of gun pointing as practised in the U. S. Coast Artillery during the past twenty years, consists of *aiming* and *laying; aiming* being defined in the Drill Regulations as the art of pointing a gun by means of a sight, and *laying* as the art of pointing a gun without the use of a sight.

Three cases are employed:

Case I. Elevation and direction both given by the sight.

Case II. Elevation given by a quadrant, or an adjusted scale on the carriage, and direction by the sight.

Case III. Elevation given by a quadrant, or an adjusted scale on the carriage, and direction by an azimuth scale.

When the direct fire guns of the primary armament of the modern system of coast defense were first installed, all three cases were prescribed; but Cases II and III were the ones usually employed at drill and target practice.

At first, the relation between fire control and gunnery was rather casual; but practice and drill at the new batteries resulted in various schemes of fire control, which necessarily had an influence upon gun pointing; and there came to be developed two distinct systems of fire control, one based on the use of Case II and one on the use of Case III.

The *Report of Fire Control and Fire Direction Employed at Fort Wadsworth, New York Harbor*, the report on the *Test of System of Fire Control and Direction in Pensacola Harbor, Florida, April, 1903*, and the files of the JOURNAL OF THE UNITED STATES ARTILLERY for 1902, 1903, and 1904, discuss in great detail the relative advantages of both systems. The principal advantage of the Case III system was in its fire control features; while the advantage of the Case II system, was in its gunnery, and its adaptability to emergency conditions arising from casualties occurring in battle.

The final result of these tests and experiments was the adoption of Case II as the method of pointing to be used with the direct fire guns of the primary armament. The work of the Case III adherents was invaluable in developing the system and apparatus of fire control, as shown in the article by Captain Morse, previously referred to.

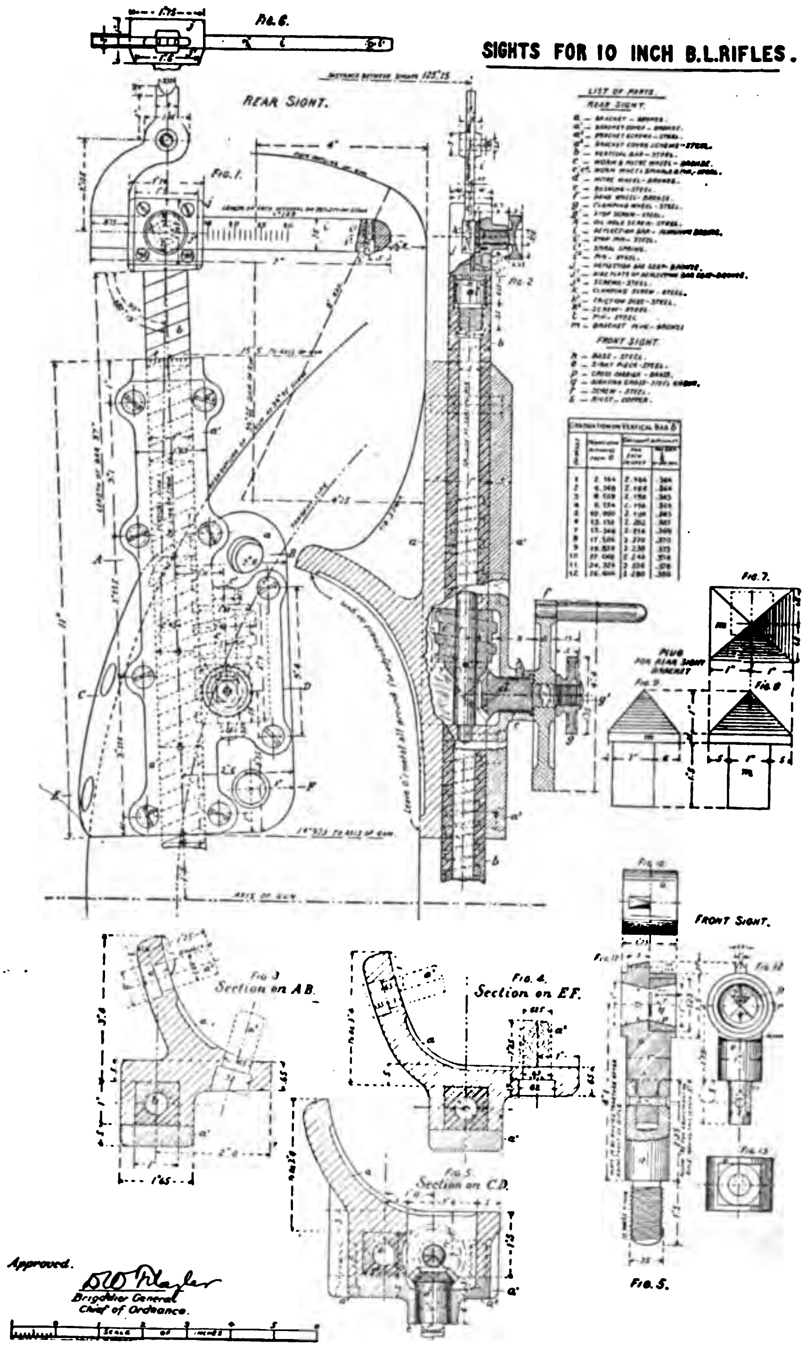
The principal lesson taught by these experiences, was that gunnery is of fundamental importance in the consideration of fire control problems; and that a fire control system must be arranged so that such casualties as may occur in battle shall have a minimum effect on the system of gunnery employed at the battery.

The mortars employed in the present coast defenses have always been pointed by Case III. It has been proposed to point them by Case II, but no tests of the value of this method have ever been had.

Rapid fire guns originally employed Case I; but nearly all of them have been modified to permit of the use of Case II, and it appears probable that the latter method of pointing will eventually become standard for all direct fire guns.

Automatic sights have never been the subject of serious test in our service; probably for the reason that the difficulty of keeping the base-ring of a gun in the degree of level required for such a system is fully appreciated.

The first sights for the modern direct fire seacoast guns were open sights. The figure shows the open sights for the 10-inch gun, those for the 8-inch and 12-inch being similar. The front sight was made of two parts, the head fitting into the base, which was left with an excess of length, so that the position of the cross-wires could be accurately adjusted at the proper height by filing off the top surface of the base after it had been screwed into its seat. The head was then securely pinned in its proper position.


SIGHTS FOR 10 INCH B.L.RIFLES.
Fig. 6.
REAR SIGHT.
Fig. 1.
Fig. 2
LIST OF PARTS.
REAR SIGHT.
FRONT SIGHT.
Fig. 7.
PLUG FOR REAR SIGHT BRACKET
Fig. 8
Fig. 9
Fig. 10
FRONT SIGHT.
Fig. 3
Section on A B.
Fig. 4.
Section on E F.
Fig. 5.
Section on C.D.
Fig. 5.
Approved.
Brigadier General
Chief of Ordnance.

The rear sight was a tangent sight made of bronze and steel. The base was secured to the breech by screws, and supported the vertical limb and the gearing that operated it. The vertical limb was a square steel bar, graduated on its rear face; and, in connection with a diagonal scale, could be set in elevation to degrees and minutes. The 8-inch sight was graduated up to fifteen degrees of elevation; the 10-inch to twelve; and the 12-inch to ten.

For the 8-inch gun, the line of the so-called vertical limb was inclined 2 degrees and 30 minutes from the vertical, as a correction for drift. For the 10-inch and 12-inch, the inclinations were, respectively, 2 degrees 45 minutes and 3 degrees.

The horizontal limb consisted of a deflection scale with a curved arm at one end projecting upward and carrying a peep-hole and a notch. The limb was made to slide horizonally through the head of the vertical limb, and was graduated on both sides to thousandths of the range. It had to be withdrawn from the head and inserted on the opposite side, when the deflection changed from right to left, or *vice versa.*

The first telescopic sight used was the "Scott Telescopic Sight." This sight was designed to be attached to a non-recoiling part of the carriage, for use in Case II; or to a trunnion bracket in Case I, in which latter event it had to be removed from its seat before the piece was fired. The telescope gave an inverted image of the target, and the field of view was small. It was fitted with an elevation scale and an inside deflection scale. No cross-wires were provided; but, instead, a pointer resembling a simple front sight was used for aiming. The pointer was moved to correct for deflection by an outside screw. This sight was so unsatisfactory that it was soon supplanted by the telescopic sight, model 1896 MI.

This sight is made non-inverting by use of the Brashear-Hastings erecting prism. Within the telescope is a sliding frame actuated by a milled handwheel from without and "carrying a vertical platinum wire 0.001 inch in diameter; also a thin glass reticule, a horizontal and a vertical scale; also a horizontal line." The vertical wire indicates deflection on the horizontal scale; and the intersection of the wire and the horizontal line is laid on the object sighted. It is provided with an elevation scale and used in a similar way to the Scott Telescopic Sight. Its optical features are as follows:

Diameter of objective, 1 inch.

Power, 8.
Field of view, 5° 5′.

The telescopic sight, model of 1897, differs from the model of 1896 MI in the substitution of a horizontal platinum wire and a horn deflection scale for the glass reticule with horizontal line and vertical and horizontal scales. Its optical features are as follows:

Diameter of objective, 1.2 inches.
Power, 9.
Field of view, 5° 12′.

The telescopic sight, model 1898, is provided with both inside and outside deflection scales, the vertical cross-wire and outside pointer being actuated by the same screw. Its optical features are as follows:

Diameter of objective, 1.2 inches.
Power, 4.
Field of view, 6° 15′.

Further development of telescopic sights produced the 3-inch telescopic sight, model of 1904, and the 2-inch telescopic sight, model of 1906.

These sights employ Porro prisms for erecting the image.

They are mounted in cradles which can be given an angle of elevation with respect to the axis of the bore, although they are attached to non-recoiling parts of the mount. This feature facilitates the use of Case I for pointing the gun.

They are provided with fixed cross-wires, outside deflection scales, elevation scales, and range dials.

Their optical features are as follows:

2-inch telescopic sight.—
Diameter of objective, 2 inches.
Power, 8.
Field of view, 4° 30′.

3-inch telescopic sight.—
Diameter of objective, 3 inches.
Power, 12 and 20.
Field of view, 3° 36′ and 2° 36′.

Rapid fire guns have been equipped with tangent sights, telescopic sights, and bar sights, of the type supplied with the Armstrong gun. The most recent are attached to non-recoiling parts and function in a similar manner to the 2-inch telescopic sight, model of 1906.

This development in the design and construction of sights has had an important bearing on gunnery.

The first sights were open, and attached to the gun itself, recoiling with it, so that the gun pointer had to take his eye from the sight and clear the piece before it could be fired. This condition led, quite naturally, to the development of Case III for firing at moving targets.

The next step in sight construction attached the sight to a non-recoiling part. Those installed on the primary gun were suitable for use with Case II only, while the bar sight on the Armstrong Gun was adapted for either Case I or Case II.

The first telescopic sight was deficient in light and gave an inverted image.

The next step was to erect the image, and this was done by means of a prism, thus further reducing the illumination. To correct this, the size of the objective was increased slightly and the power reduced. As the ranges at which practice was held increased, it became necessary to increase the power of the sight; so that, to give proper illumination, the size of the objective has now increased to three inches for the high power sights.

Recent design of sights for primary guns has also adapted them for use with Case I.

The old tangent sights and the first telescopic sights, had elevation scales graduated in degrees and minutes, thus requiring the use of a range table at the gun. The bar-sights on the rapid fire guns, however, had range dials; so that the use of a range table was unnecessary. This principle is now applied to all sights adapted for use with Case I.

The old tangent sight could be illuminated at night, after a fashion, by holding a lantern near it; but a great improvement was shown in the electrical illuminating attachment supplied with the Armstrong gun sight. The first telescopic sights were also without illuminating devices; but these were soon supplied.

The adoption of the scheme of reference numbers did away with "right" and "left" deflection, always the cause of much confusion, and constituted a real advance in gunnery.

There has been but little change in the design of the azimuth circles of guns and mortars for use in Case III. A real improvement, however, was made when the graduations were changed from degrees and minutes to degrees and hundredths, as the use of the decimal system greatly facilitates

the transmission, posting, and reading of data. An improved arrangement was given in the case of mortars, by changing the location of the pointer from the line of metal to a point convenient to the traversing stand. Case III has been used so little with guns during recent years, that no changes have been made in the general arrangement of their azimuth circles.

For laying in elevation, quadrants have been used with mortars and elevation scales with guns. The first quadrants employed with mortars were hand instruments. Later, quadrants were attached to the rimbases, and then to the trunnion of the piece. This arrangement is by no means satisfactory, as the shock of discharge is very injurious to quadrants so attached, and they make the operation of laying the piece difficult and slow. Elevation scales and range scales for mortars are now being tried, and it is expected that some form of one or the other will shortly supplant the quadrant.

The elevation scales for laying guns were first graduated in degrees and minutes, which required the use of a range table at the gun. This method was, of course, clumsy and slow, and very subject to error; so the elevation scale on the carriage was graduated for range and its name changed to range-scale.

At one time it was proposed to graduate the range-scale for different velocities, so that the velocity graduation corresponding to a given set of conditions, as determined by trial shots, could be used, thus eliminating the necessity for applying corrections to the range, as found by the range-finder; but the development of the fire control system, as described in Captain Morse's article, soon provided, for making these corrections, means which were considered to be more advantageous.

The science of ballistics in its relation to gunnery is concerned with the preparation of range tables for standard conditions, and with means for making corrections for variation from standard conditions.

Siacci's method, as adapted for our service by Ingalls, and Ingalls' tables, have been employed for the reduction of ballistic firings and the computation of the angle of departure, the time of flight, the angle of fall, the maximum ordinate, and the striking velocity, with slight changes in the method of determining the value of the ballistic coefficient, C.

For the first range tables computed for our direct fire guns, C was computed from the following equation:

$$C = f\frac{\delta_1}{\delta} \cdot \frac{w}{\beta c d^2}$$

in which

$\frac{\delta_1}{\delta}$ is the ratio of the density of the standard atmosphere to the density at the time of firing;

f, the altitude factor, to correct for the decrease in density with altitude;

w, the weight of the projectile in lbs.;

d, the diameter of the projectile in inches;

β, a factor to correct for the error caused by certain substitutions in the differential equation of motion; and

c, a factor to correct for any variation of the projectile from the standard for which the ballistic tables were computed.

The standard atmosphere was taken as conforming to the following conditions: bar., 30″; ther., 60°; saturation, 66⅔%.

To adapt the ballistic tables more perfectly to the conditions of our service, the conditions of the standard atmosphere were changed to conform to the following: bar., 30″; ther., 65⅔°; saturation 78%.

The value of f was originally determined by the following formula:

$$f = e^{\frac{h}{\lambda}}$$

in which e is the Naperian base; λ the height of the equivalent homogeneous atmosphere, taken at 27,800 feet; and h the mean height of the trajectory, taken as ⅔ y_0.

As this formula assumed the conditions of isothermal expansion, it was later changed to the form:

$$f_a = 1. + .000020\, y_0$$

this last formula being based upon Rühlman's barometric formula.

As the experience gained from ballistic firings increased, it was noted that this ballistic coefficient gave ranges for the higher angles of departure which were in excess of those obtained in practice.

Consideration of these facts led to the conclusion that the combined effect of the rotation of the projectile and the curvature of the trajectory was to cause an oblique presentation of the projectile, thus increasing its retardation.

Accordingly, the formula for C was changed, by the incorporation of a reducing factor, to the following:

$$C=\frac{\delta_1}{\delta}.\quad f_a.\quad \frac{w}{c\,\gamma\,d^2}$$

in which

$$\gamma=\frac{d^3}{2\,w}\left\{\,1+\frac{\varphi^\circ+\bar{\omega}^\circ}{135}\,\right\}$$

In the most recent firings had with the new long point projectiles, it appears that the value of $\frac{f_a}{\beta c \gamma}$ is constant for the angles of departure employed for direct fire in our service.

Under these circumstances the formula for C becomes:

$$C=\frac{\delta_1}{\delta}.\quad \frac{w}{i\,d^2}$$

where i is a characteristic index of the projectile, to be determined from ballistic firings.

The values of drift were originally computed by Ingalls' adaptation of Mayevski's formula, which for seacoast guns was

$$D\ =\ [7.7924\ -\ 10]\ C^2\ D'\ \sec^2\ \varphi$$

in which

D, is the drift in yards;

$7.7924\ -\ 10$, the log of a coefficient depending upon the twist of rifling and the characteristics of the projectile;

C, the ballistic coefficient;

D' a function given in the ballistic tables; and

φ, the angle of departure.

The present formula for direct fire guns is the well known:

$$D=(1-K)\frac{d^3}{w\,n}.\quad (\varphi^\circ+\omega^\circ)\ sec\ \varphi$$

At different times various empirical formulæ have been used for drift, the most common being:

$$D=\left(\frac{T}{K}\right)^2$$

in which

D is the drift in yards;

T, the time of flight; and

K, a constant depending upon the projectile and twist of rifling.

Corrections for abnormal conditions were first computed by means of differential formulæ; but, as improvements in the system of fire control offered increased facilities for applying range corrections under service conditions, more refined methods were thought desirable.

The corrections were then determined by making complete solutions for a given set of abnormal conditions and tabulating the results.

It was later discovered that the range corrections for a given set of abnormal conditions were not only functions of the range, but also of the height at which a given gun is mounted, so that the most recent computations take account of this condition.

The effect of wind on the range was first computed by means of Ingalls' Table I; but, as this solution was quite complex, and involved a considerable amount of interpolation, the following empirical formula was devised:

$$\Delta X = \frac{100\,W\,T}{X}\left(\Delta\,X \text{ for } .10\,\frac{\delta_1}{\delta}\right)$$

where

ΔX, is the range change in yards;

W, the velocity of the range component of the wind in yards per second;

X, the range in yards;

T, the time of flight in seconds;

ΔX for $.01\,\frac{\delta_1}{\delta}$, the range change in yards for a change of 1% in the ballistic coefficient.

Range corrections for wind are now determined by computing the change in the ballistic coefficient caused by a given wind; so that the formula for its complete value now is:

$$C = f_w \cdot \frac{\delta_1}{\delta} \cdot \frac{\omega}{i\,d^2}$$

f_w being computed by the well known formula:

$$f_w = 1 \pm \frac{2\,W\,T^{5/4}}{X}$$

The deflecting effect of cross winds was first computed by empirical formulæ, a sample being the following:

$$D_w = \left(\frac{T}{K + \frac{X}{10000}}\right)^2$$

Where

D_w, is the wind deflection in yards;

T, the time of flight in seconds;

X, the range in yards;

K, a constant, depending upon the characteristics of the projectile.

The deflection due to a cross wind is now computed by the well known formula:

$$\text{Deflection (degrees)} = \frac{Z\, D_w{}^\circ}{V}.$$

which has been deduced by analytical methods, $D_w{}^\circ$ being a function of the velocity, range, and ballistic coefficient.

Rangle tables for high angle fire were first computed by Euler's method and Otto's Tables as modified by Ingalls. Later, a complete table of high angle fire ratios was çomputed from Otto's tables, thus introducing the ballistic coefficient.

As these tables assumed the quadratic law of resistance, which does not hold for some of the velocities employed in mortar fire, a factor determined by actual firing was introduced into the ballistic coefficient.

The tables were extended and modified from time to time to make their use simpler and more convenient.

Later, a complete set of high angle fire ratiôs, based on the quadratic law, but containing a factor in C to correct for variations from this law, was computed and used for many years. The methods for computing range tables for high angle fire have recently been completely changed, the actual law of resistance, for trajectories of this character, being carefully determined by ballistic firings, reference being made to *Notes on Ballistics*, by Major Alston Hamilton, C. A. C., in the JOURNAL OF THE U. S. ARTILLERY, September-October, 1913.

These brief notes indicate in only a very general way the progress had in gunnery in our service during the past twenty years. The complete story is to be found in the files of the JOURNAL, which from its first number has been the forum for discussion, and the means of distributing information on gunnery problems of every kind. The story as there told indicates clearly the vast amount of labor and pains taken by those who have built up our system of gunnery and fire control to what it now is, and will always be a source of information and inspiration to those who follow after.

SUGGESTIONS FOR THE ORGANIZATION OF WORK IN A LARGE MINE COMMAND

By Captain HUGH J. B. McÉLGIN, Coast Artillery Corps

Distribution of Work

Table I shows the times required for the various non-simultaneous operations in planting a single group of mines with a single planter as contemplated in the *Manual for Submarine Mining*, and the total time required for the whole operation of planting a group.

The times assumed are mean for average conditions in a difficult field and the assumptions are based on personal experience and observations of good, bad, and indifferent work in the field mentioned.

TABLE I.

Order of sequence	Operation	Time required for each operation		Non-simultaneous times		Excess of time over simultaneous operations	
		hrs.	mins.	hrs.	mins.	hrs.	mins.
1	(a) Transferring 2 mis. (4 reels) of multiple cable from tank to planter (including hoisting from tank and setting on jacks on planter)..........	1	40				
	(b) Laying 1st half-mile.....	1	30				
	(c) Laying 3 subsequent half-miles..................	3	00	6	10	3	10
1	Preparing 19 single conductors, mooring ropes, and other accessories...............	3	00				
1	A group of mines can be loaded and tested in less than.....	3	00				
2	Loading mine material aboard planter.................	2	30	2	30		
3	Planting a group, not including testing and jointing.......	2	30	2	30		
	Total.....			11	10		

It is assumed that the operations of locating the distribution box, laying out the mine field, and taking soundings will be done by a vessel other than the planter and will be done while the planter is loading and laying cable.

It is apparent that, if the work of laying cable be done by another vessel, a saving in the working time of the planter of the difference between the time required to lay cable (including preparing it for laying, loading it aboard the planter, etc.), and that required for preparing the material of the group for planting, plus the time of trips to and from the mine field, will be effected.

The actual saving will, as a matter of fact, be much greater; because, with the planter moored to the wharf, the operations of measuring, cutting, preparing, and loading cables and mooring ropes may be combined.

The mines could be loaded, tested, and put aboard while these were being done.

The combination of the operations should reduce the time for preparing and placing aboard accessories by considerably more than an hour, and reduce the total time of the planter on one group to less than seven hours.

Further reductions in this time must necessarily be made in the operations of loading and placing aboard material. The time for planting is practically irreducible, until some radically different method is adopted.

It is required that single conductor cables shall be cut to prescribed lengths plus twice the depth of the water, and mooring ropes to a length sufficient to insure that the top of the mine shall be the prescribed number of feet under the surface of the water, at mean low water.

From the harbor chart accompanying the mine project, the maximum or average depth for a single group may be determined, and, as circumstances dictate, be assumed as the depth for the entire group.

To facilitate and expedite measuring, coiling, and loading, a coiling frame may be placed aboard the planter, the length of a single coil of cable thereon to the nearest convenient number of feet determined, and the cable measured in terms of coils instead of feet.

The number of feet assumed as length per coil should be that of the actual length if it be a multiple of ten, or the next greater multiple of ten.

All mooring ropes might be cut to the length equal to the

maximum depth of water for the group, the length for individual mines to be adjusted by measuring from each end one half the difference between this length and that required, placing markers of some kind (marline or tape will do) to indicate the limits of the required length. When the rope was made fast to anchor and mine all from the markers to the ends would be wasted in making the knots, or hitches.

I think it would be a wise economy of time to have most of the mooring rope* on hand cut into lengths suitable for the most important groups in the field and suitably marked, and to have the single conductor cable for at least one important group cut into suitable hanks and fitted with Turk's-heads.

The recent order requiring the numbering and study of the peculiarities of automatic anchors is a great step toward putting this material on a service basis. This will be of great value, if some standard performance be expected of these anchors, and the adjustments necessary to meet the expectation under various conditions of depth of water and strength of current be stencilled on the anchor bodies.

The longest and most tedious operation in loading mines is assembling the compound plug. If there were a side opening in the fuse can through which a vessel containing primer and fuses could be inserted after the fuse and firing circuit wires were joined, the compound plugs (less primer and fuses) could be kept assembled, and could be armed and prepared for insertion in the mine in a very short time.

The *Manual for Submarine Mining* dismisses with a few phrases the difficult operation of directing a vessel to the position for a distribution box. Officers who have determined such a position from the chart, and have attempted to direct a vessel to it by means of flags set on bearings, or by flag signals from shore appreciate its real difficulties. We all recall the troubles experienced in maneuvering tugs by signals from shore before the present system of signalling by searchlight was introduced, and realize the inefficiency of flag signals at distances beyond 2000 yards.

Distribution boxes will frequently be located at such distances from shore that it will be necessary to direct the locating vessel to position by some means more effectual than flag signals, and by some method simpler and quicker than a message by searchlight. A simple effective method might consist in pointing two searchlights so that their beams in-

*See page 110, *Manual for Submarine Mining*, 1912.

tersect at the position required. If the vessel is equipped with wireless it might be directed to position by means of one light and wireless signals.

Some good method is urgently needed. No more important duty can be imposed upon a mine commander than that of locating his mines where they are needed or required. This cannot be accomplished unless he and a suitable detail are trained in directing the locating vessel to the positions for the distribution boxes.

When directing and locating details become sufficiently expert in their duties, the bearings of enough prominent objects ashore to locate the positions of the distribution boxes should be obtained and recorded. Masters who know their harbors thoroughly may be able more quickly to determine correct positions from these data, than from signals.

If for any reason it be necessary to locate a line of groups quickly, the distribution box buoys for two groups should be correctly located and those for the others dropped at suitable distances along the line marked by these two.

Boats

The first time-saving device suggested in this paper was the laying of multiple cable by a vessel other than the mine planter.

The most suitable emergency vessel for this purpose is the "double-ender" ferryboat with a large open space extending from end to end and ample deck space at each end.

This vessel can carry enough cable for many groups and a large supply of jacks. The additions of a boom at each end, a powerful block moving on a trolley from end to end of the vehicle passage, and bolts to hold the jacks in place, would facilitate the handling of cable from shore to deck and aboard.

Even a small ferryboat with a comparatively narrow vehicle passage would have sufficient deck space fore and aft for many reels.

I believe these vessels are of light draught, so that they can stand well in shore toward the cable hut. They have records for seaworthiness, as at least one of the old timers in New York Harbor was built in the Clyde and sailed to New York under her own power, while others were used well off shore during the Civil War.

To make cable laying continuous, the cable layer should be accompanied by a fleet of smaller vessels for running cable

ashore; and to hold the ends of adjoining lengths for testing and jointing. One power yawl for the first duty and for messenger and life saving duty and as many vessels of the general type and capacity of the present D.B. boat as there are lengths to be laid for a given group should constitute the attendant fleet.

At one post where the cable end had to go well in shore and the water off shore was very shallow, the following method of getting cable ashore proved quicker and simpler than any other tried.

A windlass was placed a little farther in shore than the cable hut; the longest towing lines obtainable were bent together and about the windlass; the shore end made fast to a team of mules, the other carried out to await the planter with the cable aboard, and bent about the cable end as socn as it came overboard from the planter. At a signal from the planter the mules, and as many men as could, pulled away on the rope and the cable came rapidly ashore. The yawl which took the towing line off shore acted as a buoy for the cable while it was coming ashore.

When enough of the cable was ashore, it was made fast and signal made to the planter, which proceeded to lay the remainder of the first length. Meanwhile, the inshore end of the cable was carried to the cable hut, properly secured, and connected with the power operating board.

The continuation of the operation of laying cable would require one of the larger attendants to anchor at the proper time and place and take aboard the outshore end of the first length and the inshore end of the second, secure them, and make the necessary tests and joints while the cable layer proceeds with laying the second. When the end of this is reached the second attendant will take it and the inshore end of the third and perform the necessary operations.

There will be one vessel whose only duties will be to pass cable ends from the planter to its sister attendants already fast to cable ends—or to the D.B. boat when the end of the last length is reached—or to buoy cable, or to give other relief in an emergency. The small yawl will not be suitable for these duties in deep waters.

The tug or other vessel used to locate the positions of distribution boxes should have capacity for carrying enough marking buoys and suitable anchors for four groups. If the water is deep and the current swift the only suitable marking buoys will be No. 32 mine cases.

The original type D.B. boat is not heavy enough for duty as such in the more difficult fields, but larger ones are being provided. If none or not enough of these are available, fairly powerful tugs, with a fair amount of deck space fore or aft with a boom for lifting anchors or distribution boxes should be used.

D.B. boats should not be used for other than their own peculiar duties and should be in place to perform them whenever a planter or cable layer starts toward their position on duty bent.

Stress of weather should be the only circumstance to justify dropping the outshore end of a multiple cable into deep water without being tagged and tested and made fast to a distribution box.

In the great majority of cases I think there should be no hesitation about planting mines and leaving the single conductor ends aboard the D.B. boat, before the multiple cable has reached the latter vessel, even if it be apparent that the cable will not be gotten to it before dark.

With good illumination from searchlights ashore and afloat I would not hesitate to undertake any of the details of cable laying at night. I would not care to have to perform any other major operation in the mine field after dark.

The planter should have three attendant smaller vessels—one for messenger, life saving, and emergency purposes, and two to obtain submergences and remove buoys. These should be power boats of capacity and sturdiness equal to the type mine yawl.

These might be used as attendants to the locating vessels while the planter is loading or out of the field for other purposes, but as they would have to leave as soon as the planter arrived for planting, and as there should not be much difficulty in securing small power boats when they are needed, I think that some confusion will be avoided by providing each larger vessel with its own attendants. The locating vessel will need only two. Their duties are outlined in the *Manual for Submarine Mining.*

Soundings for any group could be made by the planter attendants while their parent vessel was loading at the wharf, and the record thereof telephoned to shore by any convenient open cable or passed aboard when the planter arrived in the field.

The number of vessels required will depend upon the total

number of groups to be planted, the number to be planted in extremely difficult waters (some will require at least one day per group), the average time per group, and the time in which war conditions demand that the harbor be closed.

For a field requiring twenty groups which must be planted in one week, the following fleet might be the smallest required.

	Launches	Planters	D. B. boats	Ferryboats	Tugs	Yawls
One fast powerful launch for mine or fleet commander............	1					
Planters with 3 attendants each		3				9
Locating vessels with 2 attendants each					2	4
Cable layers with 3 large and one small attendant...............			(*9)	3	*9	1
D.B. boats special design or tugs			3			
Total	1	3	3	3	11	14

* Either tugs or type D. B. boats.

The officer commanding this fleet will have his hands full directing it and will need a special vessel to enable him to get quickly about the field to oversee work and to straighten out difficulties.

The docking space at most coast artillery posts is too limited to permit of more than the planters tying up overnight. If the weather is good the other larger vessels might anchor near the wharf or near shore in the mine field. The cable layers could be kept at work all night getting shore ends ashore, or laying the less difficult cables.

There will usually be nearby shelter for the smaller vessels.

As the fleet should be at work on the mine field by daylight, no vessel should be permitted to berth for the night until everything necessary for the next morning's work is aboard.

Organization Ashore

There should be as many plotting details at work as there are planters, even if it be necessary temporarily to assign to the mine command one or more other baselines. Each should plot the positions of mines planted from a particular planter and, if possible, the position of all distribution boxes. The

positions of the mines may subsequently be relocated on the mine command plotting boards.

Special sections, previously discussed, should direct the movements of the locating vessels.

Getting cable ashore has already been discussed.

Loading and Preparing Mines and Accessories

This should be arranged on the basis of having one organization prepare everything to go aboard one planter.

The officer in charge of a loading section should know the number of the group he is to prepare, the kind and size of mines to load, the type and weight of anchors; and, if there be various kinds of explosives, the kind he is to use.

When a company has furnished a planting section, a D.B. boat detail, a cable laying detail, special details for the attendant vessels, and a range section, it will have few men left for loading and preparing material.

It will therefore be necessary for the mine commander to secure special details of untrained men to haul material from the tanks and storehouse to the loading rooms and thence to the wharf. Boat details should do the loading on their vessels.

An officer will be required in each loading room (in general charge of preparation of material for their own groups), in the storeroom, on the wharf, in charge of getting cable ashore, in charge of each range section, in charge of each tug directing detail, aboard each planter, aboard each cable layer, and in general charge of duties afloat. Their duties will be determined by their location.

The officer in charge of the wharf should be superintendent of traffic and harbor-master. He should supervise the moving of supplies from place to place, see that material gets aboard the proper vessels, regulate traffic ashore, distribute cars and wagons to advantage, and enforce rigid discipline in his organization.

The duties of the loading details are well understood. The officer in charge will be kept busy testing mines, enforcing safety regulations, and supervising the measuring of cable.

The coiling frames should be put ashore before the planters start for the field with their first groups and utilized for measuring and coiling single conductors for subsequent groups.

The loading details will outstrip the planters and may get so far ahead of them that the possibility of confusing materials

for various groups may arise. The officer in charge of the wharf and those in charge of loading details will have to guard against this possibility.

Overnight

The mine commander should receive reports of progress, plan the next day's work, and issue the necessary orders for it so that it may proceed at daylight.

He should check or have his range officers check the plottings for the day and have the necessary relocations made.

If conditions are favorable, cable laying should proceed throughout the night.

The mine commander should determine whether unplanted mines of a group should be planted next day or if the planter should proceed to plant a new group. It is possible that, say, fifteen mines of a group were planted before darkness compelled a cessation of work for the day, and that there may be a question as to whether it will not be better to leave the group unfinished and go on to new work.

In the event that, say, less than half of a group was planted before dark, the mine commander will have to decide whether the D.B. boat shall stay out overnight and keep the box aboard or drop it and pick it up the next day. (Raising a box with a multiple and several single conductors from deep swift waters may be a whole day's job.)

Many difficulties and delays will have been encountered during the day, and these, with new orders from above and changes in the military situation, may compel a change of plans for the next day. The mine commander's new plans must be known to subordinates in time to enable them to begin their work at daylight.

Cooperation

Coast defense and post commanders will, of course, have many other matters to attend to when war conditions exist; but no one other detail of preparation will be as important as getting the harbor quickly mined. Each post will have an influx of Reserves and laborers. The mine commander should be given all he requires to assist him. Many reserve officers will be valuable aboard the smaller vessels and in handling traffic. He should get all the boats he needs, and his wants should be considered in hiring wheeled transportation and animals.

What he will require and the sources whence he is to be

supplied should at all times be known by him, the coast defense commander, the fort commander, the quartermaster and the artillery engineer.

Peace Preparation

Mine command drills at present are fire command drills with minor caliber batteries, with the addition of simulated firing of mines.

There will be no mines to fire if the essental duty of getting quickly from the loading rooms and into the water is not thoroughly understood and frequently practised.

I believe that a mine command drill to be held once a month should consist of the preparation of all material for one group per mine company, its delivery at the wharf, and, if possible, aboard a planter or assumed planter.

During the outdoor season each company should lay one multiple cable to the most difficult part of the field.

Daily drills should be systematic and progressive. A drill should consist of the loading or unloading of a certain number of mines per day (twelve may be loaded in one hour using two details preparing compound plugs), the preparation for planting of a given number by each detail of the planting section, and the actual planting from the wharf and raising of at least one, or the manipulation of derricks and booms. Where the harbor boat used for drill has a power winch, several members of the planting detail should be aboard learning to operate it.

The essence of mine company and mine command drills should be to do at frequent intervals everything which these organizations may be called upon to do in service, so that nothing will be unfamiliar to the personnel when they are confronted with war contitions.

The drills mentioned above and the preparation of data for quickly locating the position of the distribution boxes are the most important preparations possible in time of peace. (The omission of reference to the training of casemate details and range sections is due to the fact that drill in their duties has already become a matter of routine.)

The period of the annual visit of the mine planter should be utilized for work in the most difficult part of the field, and the planter should be used as the mine commander would use it if it were sent to him for war service. Some companies may need preliminary drill, but they should not need much, and

the mine commander should be authorized to use the vessel to his advantage or that of his command while he has it.

If the arrival of the planter and a declaration of war were simultaneous, serious work would have to begin at once. If there were no planter available, one or more officers of the mine command would at once be assigned to command vessels hastily improvised as such, and would be immediately confronted with the problems whose solution is made possible only by practice and experience.

THE HYDROAEROPLANE IN COAST DEFENSE RECONNAISSANCE

By Captain V. E. CLARK, Aviation Section, Signal Corps

In Europe, under actual war conditions, the aeroplane is daily proving its ability to pierce most effectually "the fog of war"—on land. The purpose of the present article is to point out several practical uses of the hydroaeroplane as an adjunct to coast defense—to call to the reader's attention the possibilities in the use of this machine as a factor in the defense of our coast lines.

By the general term "hydroaeroplanes," I mean all heavier-than-air flying craft capable of arising from and alighting upon water, including so-called "flying boats," "aeroboats," etc.

In discussing the adaptation of the hydroaeroplane to coast reconnaissance, I will assume that the machine will always carry two men, who will divide between them the duties of pilot, observer, and signalman; and be provided with compass, other instruments, and a signal transmitting equipment. For some purposes the latter should be a wireless outfit; and for others, a smoke-puff device, such as a cylinder containing soot with apertures which can be opened and closed by the signalman. Practical tests in France have shown that a compact wireless outfit, weighing only about sixty pounds with antennæ, and not interfering with the flight of the aeroplane carrying it, is capable of sending messages sixty miles, under ordinary conditions.

Reconnaissance

(a) discovering an approaching fleet

In Fig. 1 have been indicated roughly three flight courses illustrating a plan by which, in case of an expected approach by hostile men-of-war or transports, three hydroaeroplanes might effect a more complete reconnaissance of our North Atlantic coast waters by making, back and forth, daily flights

of three hours duration, than would be possible by employing a score of the fastest destroyers.

It is not only possible, but highly probable, that, in the near future, hydroaeroplanes will be designed that will be able to "get off," make extended flights during which implicit confidence may be placed in the motor, and land without damage in almost any weather in which the navigation of a destroyer is practicable. There should, however, be some sort of breakwater sheltering the get-away and landing water areas; and, in the plan suggested, the terminal points have been chosen with this in view.

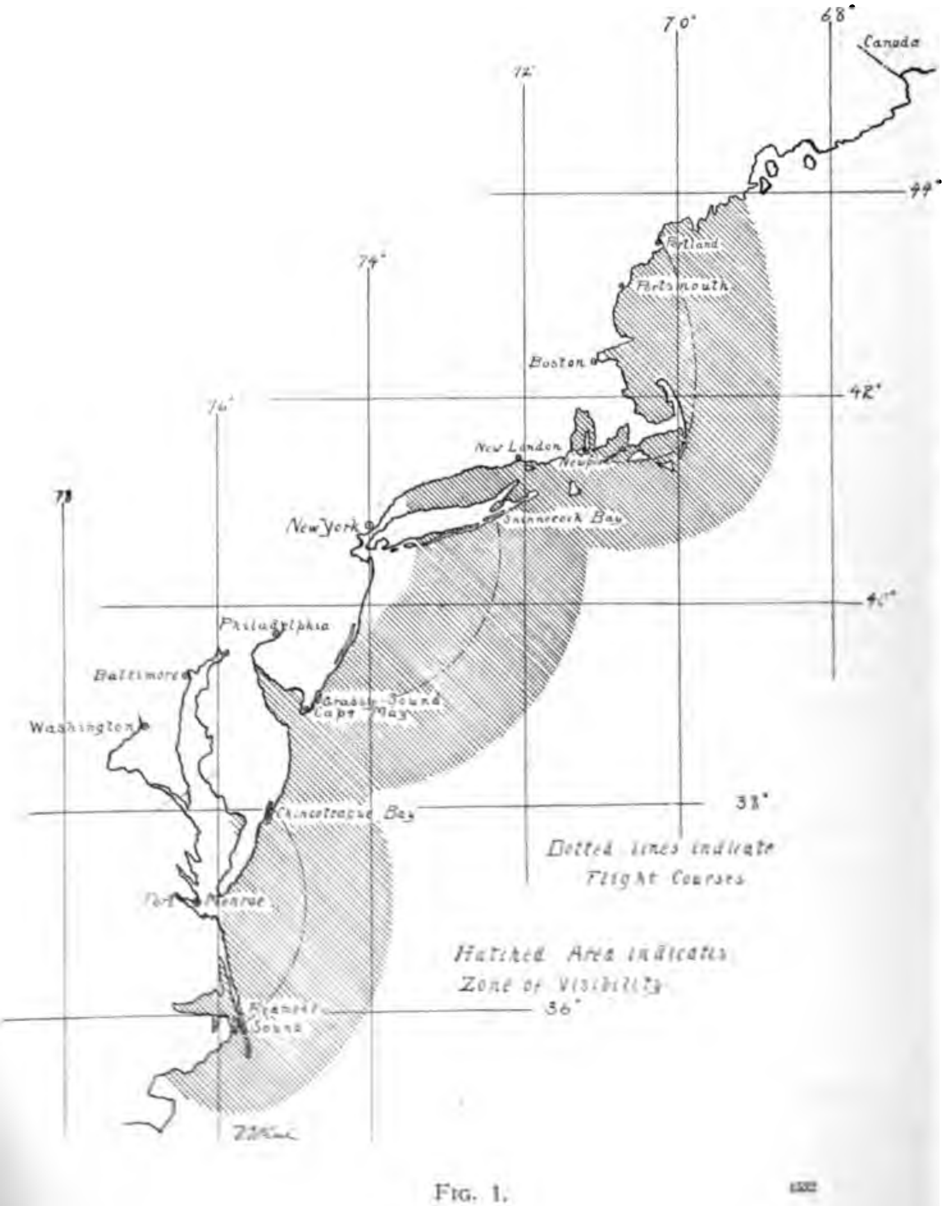
In this connection, it must be remembered that a strong wind, after having blown over a large expanse of water, may be, to the occupants of an aeroplane flying in it, no more dangerous or uncomfortable than a dead calm. Strong winds over land become broken up by hills, cliffs, cañons, and even trees or houses, until the air becomes very turbulent. On the other hand, there being none of these irregularities on the surface of the water, strong winds will usually remain fairly constant in force and direction.

At each terminal point there should be hangars, a machine shop, supplies, extra motors, spare parts, and a force of mechanicians and relief pilots.

On a day of average atmospheric transparency, an observer in a machine flying at a height of two thousand feet could "make out" a fleet of vessels at a distance of at least fifty nautical miles.

The shaded portion of Fig. 1, then, indicates the area in which the enemy would be visible to at least one of the flying scouts. After he had entered this area, the size of his fleet, the character of his vessels, and the direction of his movement would be reported to the waiting coast defense commanders.

The report would, at the very least, give the Coast Artillery personnel at New York, Fort Monroe, Boston, and Philadelphia fifteen hours, and at the other fortified points within the zone, eight hours, in which to prepare powder, fire trial shots, and even, possibly, move troops from the points not threatened to those that appear to be in danger. In the meantime, the enemy would be utterly unaware of the presence of the air scout. It is impossible to see or hear an aeroplane at a distance of even ten miles.



70°
68°
Canada
72°
44°
Portland
74°
Portsmouth
Boston
76°
42°
New London
Newport
78
New York
Shinnecock Bay
40°
Philadelphia
Baltimore
Grassy Sound
Cape May
Washington
38°
Chincoteague Bay
Dotted lines indicate
Flight Courses
Fort Monroe
Hatched Area indicates
Zone of Visibility
36°
Sound

FIG. 1.

(b) "RUN BY" IN A FOG AND MOVEMENTS BEHIND A SMOKE SCREEN

In many of our harbors, low fog banks, broken by many rifts, and extending only a short distance out from the fortified shore, are very common.

Should a coast defense commander have reason to expect an attempt to "run by," from hostile vessels behind such a fog bank, the service of a hydro might prove invaluable. The flagship would be located by circling over the harbor entrance; the observer would make a preparatory signal; and then the pilot should describe a series of regular circles, keeping his altitude constant, and passing, during the course of each circle, vertically over the target ship. The observer should cause a puff of smoke to be emitted when directly over the target. There would be practically no danger to the aeroplane from the fire of the enemy's ships. It will be found that the only fire effective against an aeroplane is that of a regiment of infantry, in which there is a very large percentage of poor shots, the resultant wide dispersion increasing the probability of the aeroplane's being hit in a vital spot, despite the usual error in estimating range.

While the hydro is maneuvering as described above, the observers at the ends of horizontal bases on shore could, using azimuth instruments capable of swinging through a large vertical angle, track, at least roughly, the course of the target as indicated by the path and signals of the aeroplane. While this method should prove particularly useful to mine commands, I believe that a sufficiently accurate track for the firing of mortar and gun salvos by Case III might be obtained.

The movements of a fleet attempting to take advantage of a smoke screen might be followed and made known to shore observers by an aeroplane using these same tactics.

(c) "RUN-BY" AT NIGHT

Should a coast defense commander expect a "run-by" under cover of darkness, he would order one of his hydros to circle over the harbor entrance. Even though the hostile vessels were running with "all lights doused," the observer in the aeroplane would be able to detect their approach by watching for the *flames down in the smoke funnels* and indicate the presence, strength, and direction of movement of a fleet by the use of Very pistol signals. Successive points in the course of a

vessel might be indicated to those on shore by dropping light bombs on the vessel when over it.

(d) LOCATING SUBMARINES AND SUBMARINE MINES

It has been found that, unless the water is very muddy, at an altitude of about seven hundred feet submarine mines are distinctly visible from the air above; and that, from an altitude of two thousand feet, the movements of a submarine torpedo-boat may be easily observed.

By employing the tactics outlined in (b), i.e., describing regular circles at a constant altitude, and making smoke puffs when directly over the target, the hydro might render material aid to the mine command in its operations against submarines.

(e) RECONNAISSANCE AGAINST LANDING FORCES

In (a) was described a method whereby warning of the approach of transports might be given.

Even after forces had landed at some point distant from coast fortifications, with the intention of operating against the defenses of the seaport from land, the movements of these troops might be followed from a hydroaeroplane as readily as from an aeroplane fitted with landing wheels. The hydro could start or land, for instance, at one of the terminal points in Figure 1, or in the harbor of the city itself. The operations of the hostile force might be reported daily from the time when they were several days' march distant.

FIRE CONTROL

(f) MORTAR FIRE AT A TARGET OBSCURED FROM FIRE CONTROL STATION BY A PROMONTORY

Should it be desired to fire on a vessel obscured from the observation of fire control stations by a high point of land, precisely the same system as has been suggested in (b) might be used to direct observation and the firing of mortars. The hydro should maintain an altitude most convenient for tracking by the base end azimuth instruments. A simple system of signals might be used to indicate to the fire commander the relative location of the center of impact and the target, at all times during the firing.

(g) INDIRECT MORTAR AND HOWITZER SHRAPNEL FIRE AGAINST LAND FORCES

Information, sufficiently accurate for indirect shrapnel

fire, as to the position of the enemy "on the other side of the hill," might be obtained through use of the hydroaeroplane. Also, during this fire, corrections in elevation and azimuth might be made from information obtained from signals sent from the flying hydro.

(h) SPOTTING FOR EXTREME LONG RANGE FIRING

Suppose a fleet of the enemy's dreadnoughts should open a bombardment at a range of, say, twelve to fifteen thousand yards, against the protected city or against the fortifications. Should an attempt be made by the shore batteries to silence this bombardment, it would be next to impossible to determine, especially if the observing stations were located only a little above sea level, whether the center of impact were "over" or "short" of the target ships.

A hydroaeroplane, equipped with wireless, circling over a line normal to the line of fire drawn from the target, as close to the target as safety permitted, could, by using a simple code, keep the fire commanders on shore constantly informed as to the proper range corrections.

The observer could use, for determining range errors, a range rake the cross arm of which is capable of movement and adjustment along the beam "observer to target," which should be graduated. The distance from observer to target, to be laid off along this beam, may be obtained by short computation, from a table, or by a simple instrument. The two values required are: (1) the altitude of the observer, which may be read from an aneroid barometer; and (2) the angle, in a vertical plane, at the aeroplane, between the two lines: (a) vertical through aeroplane; and (b) aeroplane to target. The angle (2) may be obtained by an instrument, sheltered from the wind, consisting of a weighted arm which hangs vertically, with a graduated (sextant-like) arc attached, along which a simple sight (observer to target) may be moved; and the required vertical angle read.

OFFENSE

(i) DROPPING BOMBS ON DESTROYERS AND COUNTER-MINING CRAFT OBSCURED FROM SHORE OBSERVATION

If, because of fog, darkness, searchlight out of service, or inconvenient location of mine field with relation to rapid fire batteries, these batteries should be unable to fire effectively on

counter-mining craft or destroyers, the hydro might be of great aid to the mine command by dropping explosive bombs on the hostile vessels from a low altitude.

(j) ATTACKING DIRIGIBLES

Should our coast forts ever be threatened by bomb-dropping dirigible balloons, hydroaeroplanes should form an effective means of defense.

Possessing superior speed and mobility, and presenting a much smaller and more erratic target, they would be a constant menace to these monsters of the air. We have records of at least one, and probably two encounters, during the present European war, in which patriotic French pilots have, by plunging their machines headlong into the envelopes of Zeppelins, demonstrated that, by the sacrifice of one man, a hostile dirigible, representing from twenty five to one hundred and fifty men and hundreds of thousands of dollars in fighting material, may be rendered a complete loss.

Experience may prove that it is possible to destroy a dirigible from an aeroplane by the use of a hand arm firing small explosive shell, or by throwing into the top of the balloon a harpoon to which is attached a bomb with time fuse, diminishing, to some extent at least, the danger to the pilot of the attacking aeroplane.

PARALLELISM OF THE SIGHT-ARM AND THE AXIS OF THE BORE*

By First Lieutenant AUGUSTUS NORTON, Coast Artillery Corps

In the figure, the line EF represents the distance between the axis of the gun trunnions and the axis of the elevating band trunnions; the line FM, the length of the elevating arm, measured from the axis of the elevating band trunnions to the center of the elevating pin; the line DC, the length of the sight arm; and the line BG, the length of the sight elevating arm.

The relation existing between those four lengths is expressed by the proportion,

$$DC : EF :: BG : FM,$$

which, upon the substitution of numerical values, becomes

$$28.4999 : 120 :: 41.6821 : 175.5$$

in which the ratio between related terms is 1 : 4.210541.

ABCD is a rigid rectangle, and the side DC, the sight arm, is parallel to EF, the axis of the bore. The elevating screw and the sight-elevating screw are parallel, as indicated in the figure, and both are simultaneously rotated by one and the same hand-wheel. Hence, in order that the proportion given above may hold true, the sight-elevating arm and the elevating am must be parallel; and in order that those arms remain parallel, it is necessary that, as their ends are simultaneously moved up or down on their respective screws, the distances through which the ends move shall be proportional to the lengths of the arms; that is, when the end of the sight-elevating arm, BG, moves 1 inch, the end of the elevating arm, FM, must move 4.210541 inches.

It remains to be shown, then, that, by turning the elevating hand-wheel, the travels of the ends of the two arms, BG and FM, will have the ratio 1 : 4.210541.

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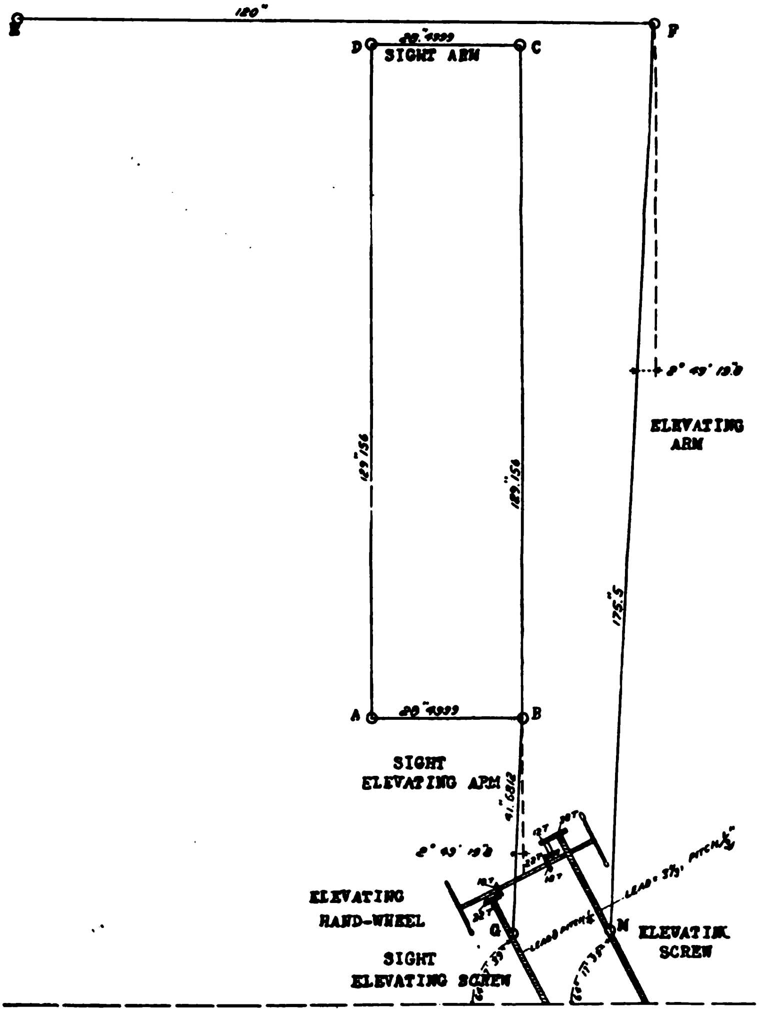
* For a description of the sight-laying mechanism of the disappearing carriage, model 1901, see Ordnance Department pamphlet No. 1697, of 1911, pages 22 and 23.

Assume one complete turn of the hand-wheel. The elevating screw will revolve $\frac{18}{22} \times \frac{12}{38}$, or approximately 0.258373, of a turn, while the sight-elevating screw will revolve $\frac{18}{22}$, or



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approximately 0.818181, of one turn. The lead in the case of the elevating screw being $3\frac{1}{3}$ inches, and in the case of the sight-elevating screw $\frac{1}{4}$ inch, the respective distances traveled by the ends are

$$0.258373 \times 3\tfrac{1}{3} \text{ inch} = 0.861243 \text{ inch}$$

and

$$0.818181 \times \frac{1}{4} \text{ inch} = 0.204545 \text{ inch.}$$

Since, therefore,

$$0.204545 : 0.861243^* : : 1 : 4.210541$$

the gears are so proportioned as to give the proper relative movements of the arms.

Let us now apply the foregoing to verification of the parallelism of the sight arm and the axis of the bore.

When the end of the elevating arm is moved down the screw 4.210541 inches, the end of the sight elevating arm will move 1 inch, as we have just seen, the two movements being transmitted, respectively, to the rear end of the line EF, which represents the axis of the bore, and to the rear end of the line DC, which represents the sight arm. But EF and DC are both pivoted at their front ends, E and D; so any movement of EF about its pivot will require such a movement of DC about its pivot as to maintain the parallel relation. Therefore the distances moved by the points F and C must be proportioned to the lengths of the lines EF and DC. Now it is obvious that the movements transmitted to F and C have the same ratio as the movements of the points M and G; for M is connected directly with F, and while G is connected to C through B, yet any movement of the arm AB about its pivot A will cause an equal movement in the arm DC, due to the fact that the parallelogram ABCD is rigid. Therefore, if the movements of the points M, and G bear to each other the ratio of the lines EF and DC, parallelism of the sight arm and the axis of the bore will be maintained.

We have already seen that M and G move in the ratio of the lines FM and BG, while the proportion

$$DC : EF : : BG : FM$$

is basic; so the parallelism is verified.

* Strictly, assuming the first term as 0.204545, this term should be 0.861245, the computations not having been carried sufficiently far in decimal places to cause the proportion to be apparent beyond the fifth place.

A SUGGESTION REGARDING POWDER CHARGES FOR TARGET PRACTICE, 1915

FIRST LIEUTENANT WILLIAM S. DOWD, COAST ARTILLERY CORPS.

The lecture given by Major F. K. Fergusson, Coast Artillery Corps, at the Coast Artillery School in August, 1914, and the article by Major E. P. O'Hern, Ordnance Department in Vol. 40, No. 2 (Sept.-Oct., 1913) of the JOURNAL OF THE UNITED STATES ARTILLERY, both attribute to the preparation of propelling charges an important rôle in overcoming erratic results in target practice. A similar conclusion was arrived at by the author in 1910 as a result of investigations made that year.

At that time, incidentally to investigating the sources of error at Battery Bloomfield, Fort Hancock, a large sheet had been compiled showing all available information about trial shots and calibration practice, when the board for "Investigation of Guns and Carriages," of which Major Alston Hamilton and Capt. P.P. Bishop, both of the Coast Artillery Corps, were members, was convened at Sandy Hook; and since their program included an extensive test of the same type of gun and carriage, there was no object in the writer's carrying his test further. But the data already considered led him to one conclusion, namely, that the way the propelling charge was prepared and placed in the gun had a great deal to do with the accuracy of fire.

It appearing from target practice reports available at the time that the number of sections did have much to do with accuracy of fire, the next step was to find out what had already been ascertained in regard to the matter; and on talking it over with officers of Ordnance, the writer was told that the subject had been thoroughly investigated some years before, and that there were no grounds of support for the appearence, as no changes in accuracy had been found to result from changes in the number of sections in the charge. However, the writer felt that from the considerations of the reports a very marked

relation to the number of sections could be seen in the dispersion of the shots; for in the case of the 6-inch gun with one section the apparent dispersion was least; in the case of the 10-inch gun with two sections, next; and in the case of the 12-inch gun with four sections, greatest.

With this as a basis the writer urged officers of Ordnance to consider further experiments, as the other tests had been made some years ago and modern conditions of target practice might have introduced factors that had not existed before. The conclusions expressed by Major O'Hern and Major Fergusson seeming now to support this view, consideration of a service test to be made during the target season of 1915 would appear to be in order.

The test could be carried out at forts with little or no expense, one of two methods being followed, either of which should give satisfactory and conclusive results.

The first method would apply to all 10-inch and 12-inch batteries.

For the 10-inch, remove one end of each section and sew the open ends together so as to form a single long section which can be laid in the loading tray. Then sew one of the ends removed, with igniter intact, over the forward end of the new long section. This will result in a reinforced igniter, which should be marked with red paint to indicate that it is to be the end next the projectile. The powder in the end taken from the other section should be removed, except for a small ring of sufficient diameter to insure ignition of a central tube which is about to be explained.

Observation of recent firings indicate that if ignition begins at the rear of the charge, the whole charge is thrown forward against the projectile, and excessive, or higher, pressures are developed in rear against the breechblock, the pressure against the projectile being lower than at the other end of the charge. The obvious correction is to ignite the charge in front; and this can be done only by some form of tube, with strong igniter at the base of the projectile. Such a tube can be improvised from cartridge-bag cloth, either supplied from the arsenal or made from reserve bags now on hand at all forts. It need only be of sufficient size, approximately one-half inch in diameter, to carry the flame forward from the primer to the reinforced igniter in the front of the charge, while the rear igniter need only be sufficient to insure the ignition of the end of the tube from the primer flame. The igniter could be made up of the same ap-

proximate weight of black powder as at present, but the distribution would be different and would be more likely to insure the greatest pressure against the base of the projectile and a more uniform burning throughout the charge. The central tube could be held in place with strips attached to it and the sides of the bags; and, in filling the bags, the blended powder could easily be packed uniformly around the tube, serving to hold it in place. This arrangement also does away with the possibility that now occurs of ununiform propagation of the explosive wave through the charge, due to the black powder igniters that separate the smokeless powder sections.

An additional advantage in the elimination of ununiform pressures to be expected from the suggested experimental preparation of powder charges, is found in the facility which it affords not only for controlling the two-inch space that is desired between the powder charge and the top element of the wall of the chamber, but also for causing any vacant space that that may be due to the charge's being shorter than the chamber to fall at the front end of the charge, next to the projectile. Both can be accomplished in filling the bag on the tray and in ramming so as not to jam the charge tight against the base of the projectile, but rather to leave it so that the air space shall be in front, in which case the resultant tendency of the charge to move back will give the highest pressure against the base of the projectile, where it is desired.

For the 12-inch guns a similar method could be used, except that both ends of two sections would be removed to form one continuous bag and the igniters used to reinforce the forward end and to fill the central tube.

Before the use of serving trays was adopted, the large charge would have been too heavy to handle; but with the serving trays no difficulty in handling or loading is to be expected, while there may result advantages of uniform pressures sufficient to eliminate the irregularities at present met with in coast artillery target practice.

The above method is suitable for use at all forts; but, if for any reason it is not considered desirable to make such an extensive test, the following alternative method could be substituted.

Powders of the following lots have given very uniform and satisfactory results: DuPont lots of 1901 and California Powder Works lots of 1901—particularly Lot 5. This latter lot has been used to the writer's personal knowledge in a 10-inch

gun practice at Key West, in 10-inch and 12-inch practices at Fort Hancock, and in the student officers' battle practice at Fort Monroe, and has given good results in all cases.

If sufficient of those lots still remains on hand, it should be assigned to certain batteries that would do the greatest amount of firing, for use in the manner described above; and the results obtained should be compared with what has been obtained with this same powder in the cases referred to above, as well as in any other cases where results have appeared consistent and satisfactory.

It has been the writer's observation that results of tests conducted by the Ordnance Department often do not agree closely with results obtained under service conditions. This is probably due to the fact that at the Proving Grounds, tests being conducted under conditions that permit of the greatest care and accuracy in all details, the poorer of two methods will compare more favorably with the better than would be the case were the two tried out at a post or in target practice, under entirely different conditions. Therefore, to obtain a service condition and make a test of the powder that will correspond with actual conditions as they exist in service firing, such a test as outlined above could better be made in target practice by the Coast Artillery, than by the Ordnance Department at the Proving Grounds. And in the case in question, making the test at target practice is the more readily practicable as little or no expense attaches to it, the necessity for a special appropriation or allotment of funds for material and equipment, therefore, not having to be considered.

PROFESSIONAL NOTES

THE ARMAMENT OF COAST DEFENSES, WITH CONSIDERATION OF BATTLE RANGES, ARMOR OF BATTLESHIPS, AND GUNS THAT CAN BE USED

Translated from the Spanish for the War College Division of the General Staff by Lieut. HERBERT O'LEARY, Coast Artillery Corps.

The interest which began to develop in coast defenses some years ago is apparently almost dead; and the importance of the problem of the adoption of standard types of guns has not succeeded in overcoming this moribund state. On account of such lack of interest, one of the greatest merits of *The Zone beyond Range*, a worthy book written by Captains Izquierdo and Alvarez Cienfuegos, is, in my judgment, its tendency to lessen apathy and to substitute therefor general discussion, both in print and conversation, of the whole subject of calibers. But, notwithstanding the book, few have expressed their opinions in the *Memorial*, the natural place to look for them. Lieutenant Ripoll, however, deserves much praise for having been one of these few.

In an extensive and, on the whole, well considered article published in the July, 1913, number of the *Memorial* under the title *El Artillado de la Peninsula P*, he advocates a caliber of 240 mm. (9.5 in.) as a maximum; but since he has, in my opinion, made some grave errors in parts of his work to which he has given prominence, I will endeavor to point out those errors and to demonstrate the absolute necessity of calibers greater than 305 mm. (12 in.) for placing our coasts in a state of defense.

The following propositions summarize the essential parts of the article:

1. At battle range no shell will perforate the armor of battleships.
2. Fire against battleships will have to be with a semi-perforating shell whose explosive charge is ten per cent of its weight.
3. In order that the weight may not be incompatible with rapidity of fire, the caliber of the gun used should not exceed 240 mm. (9.5 in.).

I.

In order to determine the accuracy of the first statement, let us consider, first, the range at which battles will be fought; second, the armor of battleships; and third, the cannon which it is possible to employ.

1. RANGES

In order to form an idea of the ranges at which it will be necessary to fire at a battleship, it is necessary to understand the forms of attack which the latter will employ against land batteries.

The direct attack, naturally, will be omitted, because of the great defensive superiority of land batteries. On pages 75 to 77 of the article referred to, this is clearly demonstrated; so there is no reason for dwelling further on the point here.

Instead of a direct attack against seacoast batteries, an attack against a fleet under protection of the batteries will frequently be met with, especially if the fleet be in a navy-yard, as will generally be the case. This will be the most frequent operation of battleships against a coast; and, since the destruction of the enemy is the primary and only object of a fleet, if the enemy's fleet has sought the protection of a navy-yard, it becomes necessary to attack in order to destroy it, firing, not against the batteries, but against the shipping and ship-yard, in order to destroy the latter, with the means of construction and repair it contains. The ships will not be able to make a direct attack on the batteries; hence the alternative course of action is either to bombard the fortifications or to leave a squadron in observation outside the fortress, since it is necessary to avoid the "fleet in being"—a term to be attributed, not to Admiral Colomb, but to Lord Torrington, immediately after the battle of Beachy Head in 1690.*

Of the two solutions indicated for the offensive fleet, the leaving of a squadron in observation is hazardous, on account of the weakening effect, unless the protected squadron of the enemy constitutes almost the entire naval force of the country. Only in such case is it possible or expedient to assemble in force outside the navy-yard, it being, as a general rule, necessary to resort to bombardment.

The probability of a bombardment's being effective is practically certain, when one considers the size of navy-yards, which always present excellent targets. For example, of the three imperial German navy-yards, Wilhemshaven contains 5,300,000 square meters, Kiel 1,273,000 square meters, and Danzig 1,280,000 square meters; Spezia had in 1900 an area of 900,000 square meters; and Portsmouth had in the same year an area of 1,000,000 square meters. So it may be taken for granted that there will be a leeway of 1 km. in estimating the direction of fire.

If the defense does not emplace pieces more powerful than the "Peninsula P," we know that it will be impossible for them to fire beyond 15 km. On the other hand, according to the ballistic tables for the Austrian 305-mm. (12-in) gun, 40 calibers long, model 1900, published by the *Rivista di Artiglieria e Genio*, and copied by the *Memorial*, this piece has, at a range of 14 km., a probable longitudinal deviation of only 38.5 meters and a probable lateral deviation of 4.45 meters; while at a range of 18 km. the longitudinal deviation is about 56 meters and the lateral about 6.90 meters; so that the total dispersive zone at a range of 14 km. is 308 meters, and at a range of 18 km. 418 meters. Consequently, a battleship which lays her guns by well determined and prominent points of the coast, making an allowance for an error of 260 meters, would still be able to concentrate her fire in such a manner that, even without observation, all of her shell would fall in the navy-yard; while if a system of observation be provided, as by means of a hydroplane, a means which is maintained by all navies, or by other means, she will be able to direct her fire to selected points in the yard.

Privately owned ordnance establishments are not so extensive, inasmuch

* The phrase does not mean an aggressive squadron, because an aggressive squadron is an offensive element, secure, because of its strength, and ready for action at the outbreak of hostilities; but an inferior fleet on the offensive, and one which, unable to dispute in battle the command of the sea, waits for the arrival of reinforcements or for a favorable moment to join other friendly fractions; one which endeavors to annoy a superior enemy, causing him to expend his fuel and to foul his bottoms, harrasing him and facilitating the attack by one's own torpedoboats in order continually to weaken him; one which expects to force the enemy to divide his forces into incomplete squadrons and then to attempt to defeat him in detail: the "fleet in being" is, in fact, the spirit of the strategic defense.

as those belonging to the firms of Weser and Bremen each contain less than 600,000 sq.m., that of Blohm & Vos 460,000 sq. m., and some others from 225 to 300 thousand sq. m.; yet it is possible even in these cases to take for granted that there will be a leeway of at least 500 m. in estimating the direction of fire, thus enabling a ship, as far distant as 18 km., to drop all her projectiles in the works.

Let us suppose that we have a squadron of only eight battleships, each one carrying ten pieces of the kind just cited, and each piece provided with twenty-five rounds of ammunition, a total of 2000 shell. This amount of ammunition would destroy much in the yard if the fire were well directed, and in any event would cause great confusion. If instead of the 305-mm., 40-caliber piece, which has an initial velocity of only 700 meters per second and fires a projectile weighing only 445 kilograms, we consider a piece of greater caliber, one made by the Krupp firm for example, which with the same length of bore has an initial velocity of 840 meters per second and fires a much heavier projectile, it will immediately become apparent that the accuracy will be much greater, especially at long range; and, consequently, that it will be much easier to direct the fire, even with a relatively smaller target. From this we see that fire at ranges of from 18 to 20 km. is not such an impossible consideration as one is accustomed to suppose, when speaking of fiie at invisible batteries.

Captain Barron of the English Artillery in the September number of the *Journal of the Royal Artillery* says:

"The views of our Admiralty on the forms of attack likely to be met with are as follows:—

"1. *Attack by squadrons of battleships.* Improbable when the defenses are likely to cause damage which would be disadvantageous in a subsequent naval action.

"2. *Bombardment of dockyards.* Is to be provided against up to 18,000 yards or 10,000 yards according to feasibility of observation of fire by the attacker."

And further along he says:

"Firstly, to deal with long range bombardment, we must have a heavier gun. It should be able to deal with vessels lying at a distance of 20,000 yards, with sufficient accuracy to deter them from coming in to a shorter range."

The idea of fire at long range has been justified, if not at exactly 18 km., yet somewhere between 16 and 20 km., but always at the shortest range which the land batteries will permit; thus the ships will approach until they encounter serious danger and it becomes indispensable to stop or to move farther away. The 240-mm. (9.5-in.) gun with a maximum range of 15 km., has, at this range, a dispersive zone very similar to that of the large calibers at a range of 23 or 24 km., which is the maximum range of the 355.6-mm. (14-in.), 40-caliber Krupp gun; that is to say, it (the 240-mm. (9.5-in.) gun) has a completely useless fire effect, since it will not be possible to fire effectively on a target as small as a battleship at a greater range than 10 or 12 km. However, if we permit a fleet to approach to within this distance, the fortifications, the navy-yard, and the protected fleet must all fall. Suppose, for instance, that the offense should have only eight battleships of the "Iron Duke" class, carrying all told eighty 343-mm. (13.5-in.) guns and one hundred twenty-eight 152-mm. (6-in.) guns: all of the guns will be able to fire at the range in question, for, although the dispersive zone of the smaller piece will be considerable, yet that is of little importance in bombarding

targets of great extent. The rapidity of fire of the larger piece, is, approximately, 1.5 shots per minute; and of the latter, 10 shots per minute; so that in ten minutes of fire the fleet will have hurled toward the navy-yard or toward the port a rain of 12,800 of the smaller projectiles and 1200 of the larger, destroying everything and enabling the fleet to retire without having suffered any damage to speak of at the hands of the batteries, for the latter will scarcely have been able to engage in fire of any efficiency at all.

Why subject the fortifications to this danger? Why permit the secondary armament of ships, which is so numerous and strong, to enter the action at all? How can the coasts be defended with pieces which are not able to keep a fleet at a distance?

2. ARMOR

In order to demonstrate the uselessness of fire for penetration, the author offers an analysis of the "Invulnerable," a ship proposed by Cuniberti, but which probably will never be adopted. Then, further along, in order to study the advantages of 240-mm. cannon using semi-perforating shell, he provides for a type of ship in which is sacrificed, in large measure, defensive power (which heretofore has been looked upon as the chief characteristic of the ship of the future), in order to increase the caliber of the ship's artillery and to demonstrate its helplessness in an engagement with the batteries, a thing which should be capable of discussion, but which does not alter in the least the reasoning of the *The Zone beyond Range.*

Of the battleships constructed or under construction, the best example is the *Pennsylvania,* which has armor 356 mm. (14-in.) thick on its water line, the greatest thickness of armor carried by any ship in any country. This thickness has been made possible by the great saving in weight obtained by employing liquid fuel exclusively. In England the *Malaya,* which will carry no coal at all, or at most a very little, will not have more than 342 mm. (13.5 in.) of armor on the water line; in France the *Normandie* will have amidships 320 mm. (12.6 in.) of armor, decreasing to 180 mm. (7 in.) at the extreme ends, so that, although admitting that there is a thickness of 4 meters of coal, which the article takes for granted, and taking the equivalent of a meter of coal to be 21 mm. of Krupp steel, there would result a maximum thickness of only 400 mm. (15.75 in.) amidships and 260 mm. (10.25 in.) at the ends. However, it is not to be supposed that the ship will carry 1700 tons of coal above the water line, for its predecessor the *Bretagne* carries a total of only 2700 tons, the remainder of the fuel being liquid, and the greatest quantity of coal which will be carried by any ship constructed or under construction up to the present time is only 4000 tons. The only battleships which will carry this much coal are the Argentine ship *Moreno* and the Chilean ship *Almirante Cochrane,* whose armor belts will not exceed 305 mm. (12 in.) and 279 mm. (7 in.) respectively, and it is not credible to suppose that if a ship carries 4000 tons of coal it will have nearly half of this amount above the water line—much less so upon arrival before a fortress, when it will have consumed part of the supply and will have taken it from the upper bunkers in order to preserve the stability of the ship.

There are, therefore, many reasons why, for the present, it is not necessary to anticipate that the land batteries will have to fire against armor the equivalent of 400 mm. (15.75 in.) of Krupp steel. However, admitting that thickness, it will be applied to a small portion of the ship only; so, it is thought

that the type of armor which *El Artillado de la Peninsula P* assumes, is typical, but it is otherwise with that of the "Invulnerable," which is only an exaggeration of the *Nevada*.

Comparing the "Invulnerable" with the *Pennsylvania*, we see that the main ideas are the same, but that the *Pennsylvania* carries ten 355.6-mm. (14-in.) guns in place of the eight which Cuniberti proposes, and that the secondary batteries consist of twenty-two 127-mm. (5-in.) guns and fourteen 152-mm. (6-in.) guns, respectively; and, although this difference is small, the American type with its displacement of 31,900 tons (33,000 at full load) has a speed of only 21 knots, while the "Invulnerable," with a displacement of only 29,700 tons, has been credited with a speed of 25 knots. It is thus seen that he treats of a type of battleship which is purely theoretical, and one which, notwithstanding the fact that the author is an indisputable authority, the Italians have not yet adopted.

What has been said surely points to the exclusive use of liquid fuel, oil having already been adopted in Italy and the United States, and almost all the other countries having favored its use, whether or not they are producers of petroleum; and taking into consideration the fact that coal, on account of its weight, would make still more impossible the speed cited, it is possible to assert that, even in the "Invulnerable," the protection will not be greater than 400 mm. (15.75 in.) of armor.

3. CANNON OR PROJECTILES

Writing on this subject in 1907 Admiral Melchior said in *La Marine et la Défense des Côtes:* "In order to fight against a battleship, inflicting in the great majority of cases damage which, although not putting it definitely out of action will at least oblige the crew to abandon her, it is necessary to have a gun with a flat trajectory, power to penetrate, etc. In short the same kind of artillery as that employed on battleships is necessary. If the Navy has hit upon the proper gun and projectile to use against ships, how can the War Department hope to obtain better results? In other words, if the War Department continues to build our seacoast batteries, it ought to adopt the Navy matériel—the guns as well as the projectiles."

Colonel Rouquerol, in an article published in the *Journal des Sciences Militaires* in November, 1909, and partially reproduced in the *Memorial,* says in defense of a caliber of 240-mm. (9.5-in.): "The hulls of the ships being the only targets of the seacoast batteries, it appears logical to urge that they be armed with guns of the same class as the ships. The seacoast batteries, moreover, have the advantage of not having to be limited in size by the weight of the guns and carriages or by lack of space. But no motive will justify the complete abandonment of all the guns which are not of the more recent models."

A brief search would disclose very many other similar opinions among those who at that time defended the small calibers.

The only difference between the gun on a battleship and that in a land battery is the greater height of site of the latter; but this greater height is a defensive and not an offensive advantage: for while a ship, in order to attack an elevated and almost invisible battery, would have to approach within a relatively short range, in which, it is true, guns of moderate caliber would have sufficient power to be used, yet this is not what the ship will do; so it is necessary that the batteries be able to fire at long range. At long range the

offensive conditions are the same as if firing from a ship; thus, the difference between the angle of fall at a range of 18 km. with height of site equal to zero and the angle of fall at the same range with 200-m. height of site, is a little more than half a degree; while at a range of 8 km. the difference will not reach a degree and a half; that is to say, for all practical purposes it will be insignificant, so that we see that at all ranges the ships and batteries will fire under practically the same conditions, as regards flatness of trajectory.

The great argument of the defenders of the smaller calibers is the battle of Tsushima, and I ask: Does either navy, the Japanese or the Russian, know what effect projectiles had in that battle, and is either one able to deduce the consequences of that effect? However, the Russians, in the ships constructed after the war, adhered to the 305-mm. (12-in.) gun, increasing its length to 50 calibers, while in the secondary armament they reduced the caliber to 120-mm. (4.72-in.), which appears to indicate that the latter are intended exclusively for firing against torpedoboats and not for firing high explosive shell at battle ranges. The Japanese, in the first ships designed after the war, provided for twelve 305-mm. (12-in.) pieces, and ultimately in those of the *Fuso* type, for twelve 355.6-mm. (14-in.) pieces.

In an article published in the May-June (1913) number of the JOURNAL OF THE UNITED STATES ARTILLERY, Captain Bunker says: "We must have the projectile that 'has the punch.' In other words, our major caliber projectile must be designed, first of all, to pierce the maximum thickness of armor."

In the conclusions of *El Artillado de la Peninsula P*, its author says: "Battleships are batteries mounted upon unsteady platforms designed, principally, for firing at rapidly moving targets * * * * * * , coast batteries are batteries mounted upon fixed platforms and designed for firing at moving targets; and following this lead: Is not this difference sufficient to establish the fact that a very suitable gun mounted on board a battleship may not be so suitable on land?"

No; all that has been said previously is not sufficient, for the reason that a projectile will act in the same way and produce the same effect whether used ashore or afloat; indeed, if any difference can be deduced, it will be the contrary of that which the author maintains, in as much as the battery of the ship, on account of being unstable and on account of its rapidly moving target, will have to mount a greater number of pieces and increase the rapidity of its fire to a greater extent than the land battery, which, on account of its stable foundation and on account of having a fixed or slowly moving target to fire at has a greater probability of making good use of its shots.

Neither am I able in any way to agree with the idea that the increase in strength of cannon may have been the result of the thickness and quality of the armor. In the *Lord Nelson* and *Agamemnon* 305-mm. (12-in.) guns, 45 calibers long, and armor of Krupp steel 305-mm. (12-in.) thick, were seen for the first time. The thickness of armor in the *Dreadnought* was decreased to 379-mm. (11-in.), the size of the guns remaining the same, while the same plan was followed in the three ships of the "Bellerophon" type; but in the *Saint Vincent*, without any improvement in the material of the armor, its thickness was decreased to 354 mm. (9¾-in.) and the length of the guns increased to 50 calibers; that is to say, from the *Lord Nelson* to the *Saint Vincent* there have been two reductions in the thickness of armor, and, notwithstanding this, an increase in the length of guns.

In order to understand the causes which gave rise to large calibers, we must recall that immediately after the Russo-Japanese war a very exaggerated belief that the fire of the future would be with high explosives, which would drive in whole plates of armor and asphyxiate the crew, became general; and, as a corollary, a belief that the shell used would not have to penetrate the armor at all.

The necessity with this shell of a very sensitive fuse, which made its handling dangerous, was the first difficulty of the new theory, which did not stand the test of sober thought but fell to the ground, as a result of the French experiments on the *Iena*, which showed that armor piercing projectiles would produce as great an effect as could be desired, while the results produced by the proposed high explosive shell were very much less than had been expected. The shell which gave the most satisfactory results was the *projectile alourdi* carried by the *Danton*, which is an armor piercing shell whose weight is 440 kg., of which 13.2 kg. is melinite.

The necessity for a very heavy armor-piercing projectile with a comparatively small but very powerful explosive charge is the true cause of large calibers almost everywhere. Only in the United States was the life of the pieces, and not tactics, the reason alleged for the increase in caliber, that country maintaining that its guns had a life of only 60 shots, despite the fact that the abandonment of wire-wrapped guns and the improvement of projectile and powder had increased the life of pieces of equal caliber to some 200 rounds in almost all European countries.

The *Naval Annual* of 1911 says, concerning the causes of the increase in caliber: "The cause usually assigned—the enormously greater destructive power of shell of the heavier guns—is said to have been proved by experience gained in extended firing trials ashore and afloat."

The *Nauticus* of 1912 says: "The 50-caliber 305-mm. (12-in.) piece with a muzzle velocity of some 900 meters, a projectile weighing 385 kg., and an initial energy of 16,000 ton-meters, had reached the limit of development; and, moreover, the battle ranges having increased, the explosive effect and striking energy of the armor piercing projectile were insufficient at oblique impact. In order to increase the effect of the projectile it was found possible to increase its length to some four calibers, thus increasing the weight to 440 kg., as in the French *projectile alourdi* for the 305-mm. (12-in.) gun, model 1906. The ballistic properties of the projectile, which grow worse as the length increases; the great stability of the axis, due to the rotational force, which is required to keep the projectile from tumbling, but which makes the tangency of the axis to the trajectory doubtful; and, finally, the erosion of the guns firing heavy projectiles, all impose limitations upon the increase in length and weight. The desirable increase in penetrative power and explosive effect can only be obtained, therefore, by an increase in caliber." And later, speaking of the effect of large calibers, it adds: "*Engineering* says that the admissible weights of explosive charges are: in 305-mm. (12-in.) projectiles, 3 per cent, or 11.5 kg.; in 355-mm. (14-in.) projectiles, 3.5 per cent, or 22 kg.; and in 381-mm. (15-in.) projectiles, 4 per cent, or 31 kg. Thus the 381-mm. (15-in.) armor-piercing shell has approximately the same effect as the 305-mm. (12-in.) explosive shell with an 8 per cent charge." And if we fix upon a caliber of 240-mm. (9.5-in.) with a projectile weighing 200 kg., we see that the 381-mm. (15-in.) shell cited above is approximately

equivalent in explosive charge to two such projectiles with 8 per cent charges, besides having an incomparably greater penetrating effect.

Taking up the calculation of thickness of penetration, the coefficient of form, 0.913, which the author of the article accepts for 406.4-mm. (16-in.) projectiles, attracts attention at once.

Now, since the hollow cap has already been adopted in almost all countries and the ogive greatly elongated, the numerical value given above, which relates to the old projectile with an ogival radius of two calibers, considering as unity the coefficient for the English projectile with ogival radius of 1.5, is entirely inadmissible. The ogive of modern projectiles with hollow caps has a radius of from 4 to 8 calibers, the tendency being toward the latter; but accepting a radius of 5 calibers and assuming the law of the sines, for the application of which we take as unity the same English projectile before referred to, we obtain $i = 0.587$, or for greater simplicity in the calculations we may take $i = 0.600$, which will make a considerable error, being perhaps in some cases excessive. With this value, according to the method of Siacci, we obtain for the 50-caliber, 406.4-mm. (16-in.) piece with a projectile weighing 920 kg. and a muzzle velocity of 940 meters and a range of 20 km.: $\varphi = 10° 40' 50''$, $\omega = 16° 43' 10''$ and $v = 479.2$ m. For normal perforation the formula most generally used is De Marres'. I am using the one in official use in the United States Navy, which is a form of De Marre's with a numerical factor corresponding to American capped projectiles against armor plate of Krupp steel. In order to make allowance for obliquity of impact, it is necessary to use Rusch's formula, or a table which gives the percentage corresponding to the angle of incidence, which must be deducted from normal perforation. I have used the table which Vert has inserted in his pamphlet, *Panzer und Schiff*. With the data already given, we obtain by the American formula, $E = 329$ mm. That is to say, this piece will perforate at a range of 20 km. any plate of the armored ship which Lieutenant Ripoll assumes as a model, except the central part, in case it carries intact behind the armor the 4 meters of coal, which part is only 8.05 per cent of the total area. And if we wish to inquire into its effect on the "Invulnerable," the best way is to calculate the maximum distance at which the perforation will be 400 mm. In order to compensate for the angle of fall, which will certainly be less than 15 degrees, we will increase the thickness 2 per cent, making it 408 mm. According to the formula for perforation at normal impact, the remaining velocity necessary to penetrate this thickness is 545.93 meters, which we may suppose corresponds to $u = 540$, in which case the distance will be somewhat greater than 16 km. This discrepancy is due to the use of an inadequate coefficient of form for the projectile, and to the supposition that this type of ship will carry a thickness of four meters of coal besides all the armor.

But as I do not consider this piece practicable, on account of its length of 50 calibers, although it might be so with a reduced length, and as I am not trying to suggest a definite caliber, but to defend those calibers greater than 305 mm. (12-in.), let us see now the effects of the 381-mm. (15-in.) gun, 40 calibers long, with a projectile weighing 760 kg. and an initial velocity of 840 m.

Assuming that $i = 0.600$, we obtain $c = 8.72$, with which, at a range of 12 km., we find $\omega = 8° 53'$, $v = 538$ m., and the perforation, $E = 374$ mm. Deducting 1 per cent of this, on account of the angle of fall, $E = 370$ mm.;

so that at this range we see that any part of Lieutenant Ripoll's battleship can be perforated, if it does not carry intact the coal which he has assumed and which we have already decided is excessive.

At a range of 17 km., $\omega = 16° 46'$, $v = 449.4$ m., and $E = 289$ mm., which, after the deduction for obliquity of fire, gives $E = 281$ mm., showing that at this range 64.9 per cent of the area can be perforated, there being, moreover, 19.3 per cent of the area which possibly can be perforated on account of its thickness being only 284 mm.

Let us see now at what range this piece can perforate a thickness of 200 mm., since this is the maximum thickness over 64.9 per cent of the area of the ship. Since the angle of fall at 17 km. is, as we have seen, less than 17 degrees, we may assume that it will never exceed 34 degrees, regardless of the range; so that an increase of 10 per cent in the thickness will make ample compensation for any expected angle of fall. Taking, then, $E = 220$ mm., we find the necessary velocity, $v = 371.4$ m.; and assuming that this corresponds to $u = 340$, we obtain a range greater than 24 km.; that is to say, the maximum range is greater than 24 km.

As a proof that my method of making the calculations is the natural one and that it does not favor perforation, it should be observed that the formula for perforation used in the American Navy is sufficiently conservative and certainly gives results smaller than those of Ronca, and that the remaining velocities which I have obtained at 12 km. are 631 m.s. for the 50-caliber, 406.4-mm. (16-in.) piece, and 538 m.s. for the 40-caliber, 381-mm. (15-in.) piece, and that the Krupp tables give 655 and 560 m.s. respectively; while, on the other hand, with the coefficient of 0.913 which Lieutenant Ripoll uses, the result for the 406.4-mm. (16-in.) gun is a remaining velocity of only 528.5 m.s. at a range of 10 km. In thickness of armor perforated, the figures of the Krupp firm (590 and 440 mm. respectively for normal impact at 12 km.) are greater than my results, because they employ manufacturers' formulæ, in place of a rigid one such as I have used.

I have not attempted to calculate the perforation for 355.6-mm. (14-in.) guns, for it is thought that this has been well covered in *La Zona sin Alcance*, by Captains Izquierdo and Alvarez Cienfuegos; and, since in their pamphlet those gentlemen have also calculated the perforations with a short cap for fire against the decks of battleships at long range, I ought to observe that with the 406.4-mm. (16-in.) gun I do not think that it is necessary to discuss that kind of fire, on account of its enormous perforating power as well as on account of its angle of fall's being so small at long ranges that, even with a very short cap, it will not be possible to increase the angle sufficiently to permit of the use of this gun for attacking decks, even at ranges as great as 25 km. or more.

If we adopt a cap with an equilateral ogive for the 381-mm. (15-in.) gun, we shall have $c = 4.68$, and at 17 km. $\omega = 34° 51'$, $v = 331$ m. and $E = 157$ mm., which, on account of the smallness of the angle of fall, represents an effective perforation of 73 mm.; but, owing to the small thickness of deck armor (from 70 to 76 mm., as a general thing), the pounding effect of these projectiles of great total weight and the effect of their explosive charges against such thin plates will almost surely destroy the plates.

The results deduced from the firings against the *San Marcos*, which I shall speak of presently, agree completely with the above, the angle of fall with this cap being 44° 10′ at a range of 19 km., thus giving for deck armor a

penetrating power much in excess of that required. With this type of cap and for this kind of fire, I believe that the semi-perforating shell with a 10 per cent explosive charge would be suitable and that the effect of the fire would be truly terrible, having, as it would have on account of its thickness, the same penetrating power against the decks as the present armor piercing shell would have.

The advocates of small calibers are apt to maintain that the theoretical perforations are not obtained in practice, but the *Iena* trials demonstrated that this belief is erroneous and that the actual perforations are as great as those expected. The American experiments on the *Katahdin* and *San Marcos* were much more conclusive in this respect and demonstrated the possibility of making a great number of hits at ranges which a few years ago appeared absurd, varying, according to the *Army and Navy Journal*, from five to seven and a half miles, and concerning which the Secretary of the Navy, Mr. Meyer, says: "The *New Hampshire* placed its shots anywhere, and when it was desired to make hits on the conning tower or on the turrets in order to observe the effect, no difficulty was encountered in concentrating the projectiles at the desired point at distances of from ten to twelve thousand yards." And according to Admiral Twining, Chief of the Bureau of Ordnance, the experiments proved: (1) that theoretical perforations are obtained in practice at long ranges; (2) that armor piercing shell, upon bursting after penetrating the armor, are capable of inflicting enormous damage, even without piercing the armored deck; and (3) that an armor-piercing shell which does not pierce the armored deck, but which explodes against it, is able to destroy it, and, with its own fragments and those of the deck, to put the boiler and engine rooms out of commission.

The French Admiralty, the old advocate of a multiplicity of small offensive units, which constructed torpedoboats instead of battleships, a mistake which in truth it has had cause to regret, has begun, as have almost all other admiralties, to adopt the large calibers, and in the battleships of the "Bretagne" type has adopted 340-mm. (13.5-in.) guns (also installed in the "Normandie" type) despite a minority which advanced, in opposition, the worn arguments of increase of weight, slowness of fire, etc., etc.

Bravetta, to whom Lieutenant Ripoll very appropriately refers as an authority, says, in the *Rivista di Artiglieria e Genio* of July-August, 1913: "The author of this article believes it opportune to repeat * * * * * * * * * *that the directors of our naval artillery, by adopting a relatively light gun having a caliber of 381-mm. (15-in.), an initial velocity of 700 m.s., a projectile weighing 800 kg., and an initial energy of 22,000 ton-meters, with a life of 500 rounds of full service ammunition, have solved in an admirable manner the problem confronting them."

To those who maintain that large calibers are suitable for battleships but not for coast defenses, we will say that in the same number of the *Rivista* Bravetta says, in speaking of 381-mm. (15-in.) and 406-mm. (16-in.) pieces: "As will be seen, for each of these calibers there are three lengths, i.e., 40, 45, and 50 calibers, the last evidently destined for seacoast armament." The Schneider firm, some four years ago upon presenting comparative data for 305-mm. (12-in.) and larger calibers, concluded that the latter were at least suitable for coast fortifications. England, according to the 1913 *Nauticus*, will defend the new naval base of Rosyth, on the Firth of Forth, with 381-mm. (15-in.) guns. Captain Garrone, in the *Rivista di Artiglieria e Genio*

of the current month of September, defending major calibers for seacoast fortifications, says: "The Naval Artillery, following this plan, has been increased in caliber to 381 mm. (15 in.) which, therefore, should be the minimum caliber selected by us. The superior limit is hardly determinable, considering that in coast batteries it is theoretically possible to emplace matériel of any weight whatever." The Americans, as is already well known, have adopted for the defense of the Panama Canal 356-mm. (14-in.) and 406-mm. (16-in.) pieces, and have already mounted some of the former. This caliber has also been adopted for the Hawaiian Islands. Russia, in 1911, according to the *Army and Navy Gazette*, decided to emplace twenty 305-mm. (12-in.) and forty 250-mm. (9.8-in.) pieces on a peninsula to the east of Reval, being unwilling to adopt the large calibers on account of not having such guns on her battleships.

We thus see, as is natural, that not only for battleships but for coast fortifications as well, all countries and all technical students of the subject have committed themselves to large calibers, and at present it appears to us that in no situation would we desire to have the 240-mm. (9.5-in.) piece our weapon of maximum size and strength.

II.

After having written at such length concerning the first proposition, there remains little for me to say concerning the other two, for we have already seen that the enthusiasm which was displayed in 1906 and 1907 for the smaller calibers was short lived. Klado, DeLanessan, d'Adda, and others exaggerated the effects to be expected, while Lockroy advocated arming battleships with twenty of the 240-mm. (9.5-in.) pieces; but the fashion was of short duration, study, the example of Russia and Japan, and experimental firings bringing about, little by little, the adoption of large armor-piercing projectiles whose explosive charges, while really large, are yet only a small percentage of the total weight.

I will only speak of the experiments carried out in November, 1910, on the *Puritan*, which were conducted for the purpose of determining the effect of large explosions on heavy armor; and, if the *Iena* tests were not very favorable to high explosive shell, much less so were those on the *Puritan*. The effect of 90 kg. of explosive gelatine on a turret was almost limited to an indentation at the point of contact and to the opening of the joint between the plate attacked and the adjoining one. On the belt the effect was somewhat more pronounced and the ship was flooded; but this was due to three causes: (1) the small depth of the armor, which extended below the water line only two and a half feet (76 cm.); (2) the breaking of the holding bolts, due to the indentation of the plates; and (3) the lack of a good system of water-tight compartments such as is found in all modern ships. Universally the results are regarded as far below those hoped for. These experiments, in connection with those of the *San Marcos* and *Katahdin*, resulted in convincing those in authority that high explosives have no effect, if the explosion be not preceded by perforation; and the net result was the justification of large calibers. According to the *Nauticus* of 1912, this "proves that it is not possible to base any great hope, for effect against armor, on a 305-mm. (12-in.) projectile with thin walls, charged with some 30 kg. of a less violent explosive, which bursts upon impact"—and, consequently, much less upon a 240-mm. (9.5-in.) projectile.

If we depart from a projectile three calibers long having a 3 per cent explosive charge and wish to design another having a 10 per cent explosive charge, we may make use of the formula deduced in *Engineering* of July 1, 1910, for cylindrical projectiles, which is:

$$l_{n'} = l_n \frac{25 + n'}{25 + n}$$

Placing $n' = 10$, $n = 3$, and $l_n = 3$ calibers, and making the proper substitutions in the formula, we have,

$$l_{10} = 3 \text{ calibers} \times \frac{25}{28} = 3.75 \text{ calibers.}$$

Since the ogival part of the projectile cannot be made as thin as the cylindrical part, especially if we desire that the projectile be semi-perforating, it will not be possible to make it more than 4 calibers long; and since it is not possible to use a projectile of greater length than this, we shall not be able, in this case, to apply the elongated cap, which exhibits such remarkable advantages in trajectory. Moreover, the sides of the projectile being very weak, it will be possible to use the projectile against only such plates as have a thickness not exceeding one-half the caliber, for the reason that the projectile will be broken up against heavier plates without having more than begun to penetrate. Thus the 240-mm. (9.5-in.) semi-perforating shell will not be able to pierce at any considerable distance more than 35.8 per cent of the area of the ship which *El Artillado de la Peninsula P* places before us as a type; and, even of this fractional part, there is almost a half (17.45 per cent of the area) which, with its 102-mm. (4-in.) of armor, possibly will not be perforated at the limiting range. The 150-mm. (6-in.) armor, which is the next in thickness, will not be pierced at even 2 or 3 km., because, although the projectile will have sufficient energy, its body will be broken up at the instant of impact. And, if in place of this ship we substitute the "Invulnerable," the uselessness of this shell and this caliber will become much more evident; for, as far as it is concerned, we might as well be shut up in a strong box, the 240-mm. (9.5-in.) semi-perforating shell having no more effect than a sky-rocket, being limited to producing small fires in staterooms and unimportant parts of the ship. For this reason the author of the article cited, who takes the "Invulnerable" as a target for perforating fire, has been very careful to substitute another in the discussion of the 240-mm. (9.5-in.) semi-perforating shell.

III.

I believe that it has been fully demonstrated that fire against modern armor must be perforating fire with large calibers and explosive charges of from 3.5 to 4.5 per cent of the weight of the projectile; but if at some future time, on account of an alteration in naval construction or for any other cause, the semi-perforating shell with a 10 per cent explosive charge is considered advantageous, then at that time the major calibers will still have a very great superiority. In the first place they are able to keep the battleships at distances of from 20 to 25 km., as compared with 13 or 14 km. in the case of 240-mm. (9.5-in.) guns; moreover, a battery of two 381-mm. (15-in.), 40-caliber guns, for example, firing 1.2 shots per minute (which is the rate of fire given in tables computed by the Vickers company) will be able to hurl

at the enemy 182.4 kg. of explosive in place of 240 kg., which can be thrown by a battery of four 240-mm. (9.5-in.) guns in the same length of time, while the projectiles of the former, piercing the armor before bursting, and exploding a great quantity of powder (76 kg. each time), will have a much greater effect than those of the latter, which will cause, in most cases, an inoffensive explosion against the exterior of the armor, at the same time that those which do happen to penetrate, since they carry a relatively small charge (20 kg.), will not have a very great explosive effect. Major calibers are also able to utilize a short cap for this type of shell in the attack of decks of battleships, thereby causing an enormous amount of damage.

According to tables published by the Vickers firm, the 355.6-mm. (14-in.) gun has a rate of fire of 1.35 shots per minute; but according to the *Mitteilungen u G. d. Artillerie und Geniewesens*, the American gun of this caliber, with a 735-kg. projectile, has fired six shots in 3 minutes and 44 seconds, despite a delay due to a broken powder bag and a misfire, the third, fourth, and fifth shots having been fired in 1 minute and 34 seconds. Consequently it is not extravagant to suppose that the Krupp gun with a 620-kg. projectile is able to fire from 1.9 to 2 shots per minute; in which case a battery of two pieces will be able to throw from 2365 to 2480 kg. of steel and from 235.6 to 248 kg. of explosive per minute; that is to say, a weight equal to that of the battery which Lieutenant Ripoll assumes as typical. Furthermore, the 355.6-mm. (14-in.) battery will have the advantages already cited of greater range, a greater effective zone, and a greater explosive effect for each hit made.

In conclusion, it is necessary to note that on page 81 of the article on which I am commenting there appears a paragraph in which a comparison is made between the weight of explosive thrown by the 406.4-mm. (16-in.) gun firing an armor-piercing projectile with an explosive charge of hardly more than 4 per cent and that thrown by four 240-mm. (9.5-in.) guns firing semi-perforating shell with 10 per cent explosive charges. This hardly appears logical, since, if it is deemed preferable, it should be possible to use this type of projectile with either caliber. If we do this and take into account the advantages which major calibers have in this class of fire, we shall see that the 406.4-mm. (16-in.) gun still has many advantages over the 240-mm. (9.5-in.) gun.

The adherents of reduced calibers say that the accuracy at long range is very small, even with large calibers, and that, therefore, the probability of hitting the target will be small; but it must be remembered that the accuracy is not so insignificant as they say. If the 40-caliber, 305-mm. (12-in.) Austrian gun has a 50 per cent zone of only 112 meters at a range of 18 km., the 50 per cent zone will be very much smaller for a superior caliber which has an initial velocity of 840 meters instead of 700 and a projectile weighing 620, 760, or 920 kg. instead of one weighing 445 kg., accordingly as the caliber under consideration is 355.6 mm. (14-in.), 381-mm. (15-in.), or 406.4-mm. (16-in.). The 50 per cent zone for a caliber of 381 mm. (15-in.) will hardly exceed 50 or 55 meters at a range of 18 km.; in which case, for fire concentrated on a ship from 180 to 190 meters long and 28 meters wide, the danger will not be so insignificant as the advocates of the 240-mm. (9.5-in.) gun would lead us to believe. And furthermore, if at this distance a gun of large caliber has a small probability of hitting the target, the probability will be even less for the 240-mm. (9.5-in.) gun, whose maximum range is 15 km. and

whose 50 per cent zone at this range is approximately the same as 50 per cent zones of the three major calibers cited above at 24, 24.5, and 25 km. respectively.

Emphasis is also placed on the alleged fact that the 240-mm. (9.5-in.) piece is very much less costly than those of major calibers; but the fact that in the calculations of strength it is usual to assume twice as many of the former as of the latter, is lost sight of. This has already been mentioned, and we have seen that a battery of two guns of large caliber is very much more useful and powerful than a battery of four 240-mm. (9.5-in.) guns, at long ranges the latter being completely useless, while the former is extremely valuable. But, notwithstanding this, it surely seems that the cost of two large pieces even as great as 406.4-mm. (16-in.) will not exceed that of four small ones, and this appears more convincing if we consider either of the other two major calibers. But even supposing that the cost of the major calibers will be somewhat greater, the difference will be very small if all the necessary expenditures for a fortress are considered, such as site, construction of batteries with magazines and barracks, telemeters, searchlights, telephones, predictors, projectiles, etc.; so that if a small caliber is adopted the saving in expense will not enable us to fortify a single place that otherwise could not be fortified, at the same time that those fortifications which we do build will be very imperfect. There are also many details incompatable with economy, such as armored turrets, which, in the case of the 240-mm. (9.5-in.) gun, would be indispensable in many situations. In *El Artillado de la Peninsula P*, the author is compelled to admit that in one or another of the fortresses there are various deficiencies as a consequence of the very small power of these pieces. Why then speak of economy?

The visibility of the target need not occupy our attention, since from sites of but slight elevation it is possible to see a ship at a distance greater than 20 km., and as all modern pieces are fitted with telescopic sights the pointing of the piece can be effected admirably.

The isolated explosions which Lieutenant Ripoll mentions should not be the reason for condemning the major calibers, for in all systems and for every caliber analogous accidents have occurred. Bravetta, whom the author quotes, does not attribute these explosions to the caliber of the pieces, but to the fact that the latter were wound with wire under high tension which had produced deformations of the tube, thus causing the jamming of the projectile. It is well known that the longitudinal resistance of a wire-wound gun is small, and that, on account of its own weight and the great tension of the wire, it undergoes deformations sufficiently great to cause, not only a lack of accuracy, but also jamming of the projectile. The hypothesis of Bravetta is thus very credible and does not compromise the major calibers. But if we should attribute those accidents to the caliber, what can we say for the 240-mm. (9.5-in.) gun which recently gave such "brilliant" results in France that they have had to condemn a relatively large humber of newly constructed pieces?

"The life of guns" is another phrase which advocates of the small calibers are accustomed to abuse, forgetting that they themselves say that this was the principal cause of the increase in caliber. It is certain that increase in caliber leads, in general, to increase of erosion, because the quantity of heat developed by the explosion increases more rapidly than the surface of the powder chamber; however, this effect is small and can be diminished to a

great extent by carefully selecting the powder and by properly designing the powder-chamber. The maximum pressure, on the other hand, varies very little with the caliber, depending almost solely upon the length of the piece. *El Artillado de la Peninsula P* holds that the 2700-kg. pressure which the 45 caliber 240-mm. (9.5-in.) gun is designed for, is "a moderate value—especially in comparison with the pressures which the major calibers have to withstand." This is the pressure which it is customary to associate with the 40-caliber 381-mm. gun and, according to Lissak (*Ordnance and Gunnery*), the American 40-caliber 355.6-mm. (14-in.) gun is designed for a pressure of 2660 kg. per sq. cm., and the other gun which the author cites as an alternative, the 50-caliber 240-mm. (9.5-in.) piece, will have a pressure of 3000 kg. and a shorter life than any major caliber of relatively shorter length. The JOURNAL OF THE U. S. ARTILLERY copies a paragraph from *Le Yacht*, according to which the lives of the major calibers are:

50-caliber 305.4-mm. (12-in.) gun,	150 shots;
40-caliber 355-mm. (14-in.) gun,	240 shots;
50-caliber 355.6-mm. (14-in.) gun,	175 shots;
40-caliber 381-mm. (15-in.) gun,	300 shots;
50-caliber 381-mm. (15-in.) gun,	200 shots;

demonstrating that the life of a gun decreases as the relative length increases and increases as the caliber increases.

According to the Italian Minister of Marine (see the JOURNAL OF THE U. S. ARTILLERY for March, 1913), the German 45-caliber 305-mm. (12.5-in.) gun, the 50-caliber 355.6-mm. (14-in.) gun, and the 50-caliber 381-mm. (15-in.) gun each has a life of 200 shots. Bravetta, in the *Rivista* of July, 1913, says that the 381-mm. (15-in.) gun, with an initial velocity of 700 m. and a 850-kg. projectile, has a life of 300 shots. *Engineer* publishes a very interesting article entitled *Big Naval Guns*, in which appears a paragraph which assigns to the 233-mm. (9.2-in.) gun a life of 450 or 300 shots, according to whether the initial velocity is 840 or 875 m., and to the 343-mm. (13.5-in.) piece with an initial velocity of 760 m., 450 shots, and adds: "Accepting the usual relations and admitting a proportionate erosion, a 45-caliber 356-mm. (14-in.) gun with an initial velocity of 760 m. should be able to fire 420 shots, and the 45-caliber 381-mm. (15-in.) gun should be able to fire 350 shots before replacing the interior tube."

From all that has been said it is seen that it is useless to bring up the question of the life of guns, and that with a suitable design there should be almost no difference in this respect between the 240-mm. (9.5-in.) guns and the major calibers, and that the latter have a life sufficiently long, especially if for target practice a reduced charge be employed or, perhaps better, a subcaliber tube, such as is used by the Americans.

Although I am in favor of the two-gun battery, I do not accept as an argument of any force the comparison of land batteries with the turrets of battleships. The latter exist for two reasons—scarcity of points on board a battleship from which the desired field of fire is obtainable, and economy in weight of turrets. In the discussion had recently in France concerning the adoption of four-gun turrets for ships of the "Normandie" type, the principal argument, and almost the only one of any force, which was presented was that, with a weight 1.6 times as great as that of the two-gun turret, the number of pieces could be doubled. The simultaneous discharge of the guns

of a turret is necessary in order that the smoke of one piece shall not interfere with the pointing of the other, and since the turret is subject to an eccentric force, a rotation is produced which would greatly derange the pointing of the other piece, if it were fired before the termination of this rotation. The rotation, according to the 1912 *Nauticus* (copying from the *Rivista Maritima*), is, in the case of turrets manufactured by the Armstrong firm, as much as 2° 20′ in two-gun turrets and 4° in three-gun turrets; this has been corrected to a great extent of late, but the objection will always exist. Hence turrets for more than one gun are considered a necessary evil.

Briefly, my conclusions are as follows:

1. The battleships of a fleet will not bring on a general engagement with coast batteries, but will limit their action to bombarding ship-yards and ports of refuge at the shortest range consistent with safety.
2. On account of the great accuracy of the large caliber guns of the battleships, armament which is capable of keeping the ships at a great distance is necessary. This distance is difficult to determine with accuracy, but it will certainly always be greater than 12 km., the range which the author of *El Artillado de la Peninsula P* assumes as a maximum. It is necessary, consequently, to rely upon the major calibers.
3. If, in place of the range, we direct our attention to the kind of fire, we see that it is most natural to follow in the footsteps of the navy, i.e., to use armor-piercing projectiles with large explosive charges, which thus would also require large calibers.
4. Although supposing that, for reasons which do not now exist, at some future day the semi-perforating shell with a 10 per cent explosive charge shall be preferable, the major calibers will still have their advantages, on account of their being able to throw this charge to a greater distance, thus subjecting more of the vulnerable parts of the ship to effective fire, and because one large explosion produces a much greater effect than numerous small ones. Besides, the smaller calibers which are adaptable to this class of fire would be useless, if it were desired to employ them for the perforation of armor.
5. The objections in regard to cost, life, rapidity of fire, etc., are unfounded; or, at least, the difference in these respects between the large calibers and the 240-mm. (9.5-in.) gun is small.—*Memorial de Artilleria.*

♦ ♦ ♦

THE GERMAN SIEGE HOWITZERS

Much interest has been aroused by the statements made in the press that the Germans have been using siege howitzers of unprecedented size in the attack on the forts of Liége, Namur, and Maubeuge.

The *Berliner Tageblatt* states that the guns used were 6″ heavy field howitzers, 12″ siege howitzers, and one 16″ siege howitzer. The British vice-consul at Liége reports that two of the guns were of 42-cm. (16.8″) caliber. Messrs. Krupp of Essen state in answer to an enquiry from a Danish newspaper that 42-cm. guns exist, and are transportable by land, but decline to give further information. It is reported from Trent in Austria, that thirty-seven 42-cm. howitzers, which had been used in the sieges of Liége and Namur, arrived on September 16 for the armament of this fortress.

Finally, the *Times* correspondent writes from Ostend that he has interviewed a gentleman who traveled for some days on the same road as a German siege train of two heavy howitzers marching from Maubeuge to Brussels, which on Sept. 21, were near Waterloo. He reports: "For their hauling, the two 42-cm. guns need no fewer than twenty-six traction engines. Each is in four pieces (i.e. loads) and each piece is drawn by three traction engines, the spare engines going on ahead to be used as helpers up hills. All but two of the engines bore the name-plate of an English firm."

It will be noted that none of the authors of the above reports had any opportunity of verifying the caliber of the howitzers.

On the other hand, the Belgian Minister for War, on information received from General Michel, commanding the 4th Belgian Division, states:

"At Namur, the German Artillery employed cannon of 5, 10, 13, 15, 21, and 28 centimeters. It was the enormous 28-centimeter guns that destroyed the defenses. The fire was so continuous that it was impossible to attempt to repair the damage done between the forts. The fort of Suarlée, for instance, was bombarded from Sunday morning, the 23rd of August, and fell on the 25th, at five o'clock in the afternoon. Three German batteries of large cannon, using projectiles weighing 350 kilos, shot 600 projectiles on the 23rd, 1300 on the 24th, and about 1400 on the 25th against this fort. When the fort fell all the massive central structure was destroyed, and further resistance was hopeless."

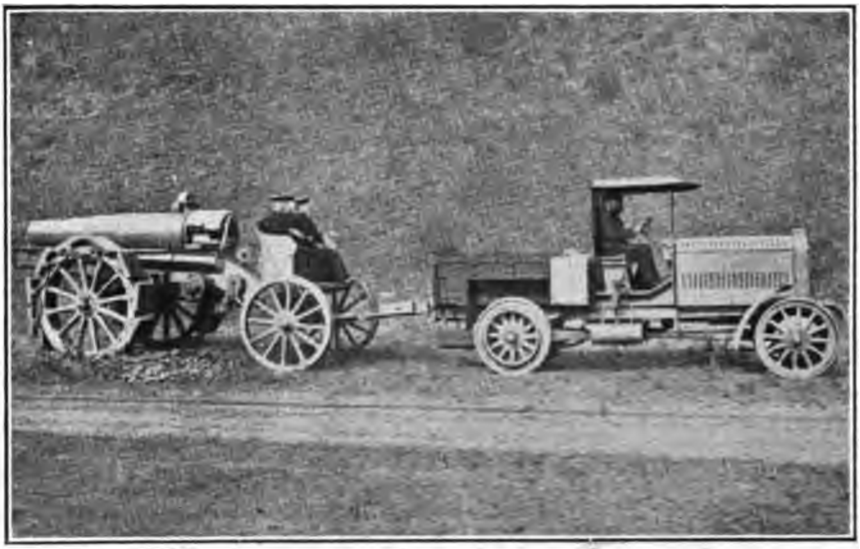
The shell of 350 kilos here referred to is that fired by the Krupp 28-cm. (11.2″) howitzer, and no mention is made of shell of larger caliber.

Now if we calculate, from the details given below of the 11.2″ howitzer, the weights of ordnance of larger caliber, we obtain, by a simple sum in proportion, the following table, in which it is assumed that the larger howitzers are also 12 calibers long and are of similar design to the 11.2″:

Caliber, inches.	11.2″	12″	13″	14″	15″	16.8″
Weight of ordnance with breech-block, tons	6.3	7.75	9.85	12.3	15.2	21.3
Weight in action, tons	14.8	18.21	23.14	28.9	35.6	50
Heaviest load to be transported, including transporting wagon, tons	9.27	11.41	14.5	18.1	22.4	31.3
Weight of shell, lbs	750	935	1188	1485	1826	2565
Weight of burster (mine shell), lbs	114	140	178	223	274	384
Recoil energy for M. V. 1000 f.s., foot-tons	381	557	708	886	1088	1530

The question which then arises, with respect to the possible existence of heavier weapons than the 11.2″ howitzer, is, first the limit of weight which it is possible to transport by road, and, second, the limit of power for a howitzer to be fired from the ground, that is, without a permanent concrete bed.

We have first to consider the information available about the existing 28-cm. or 11.2″ howitzer.

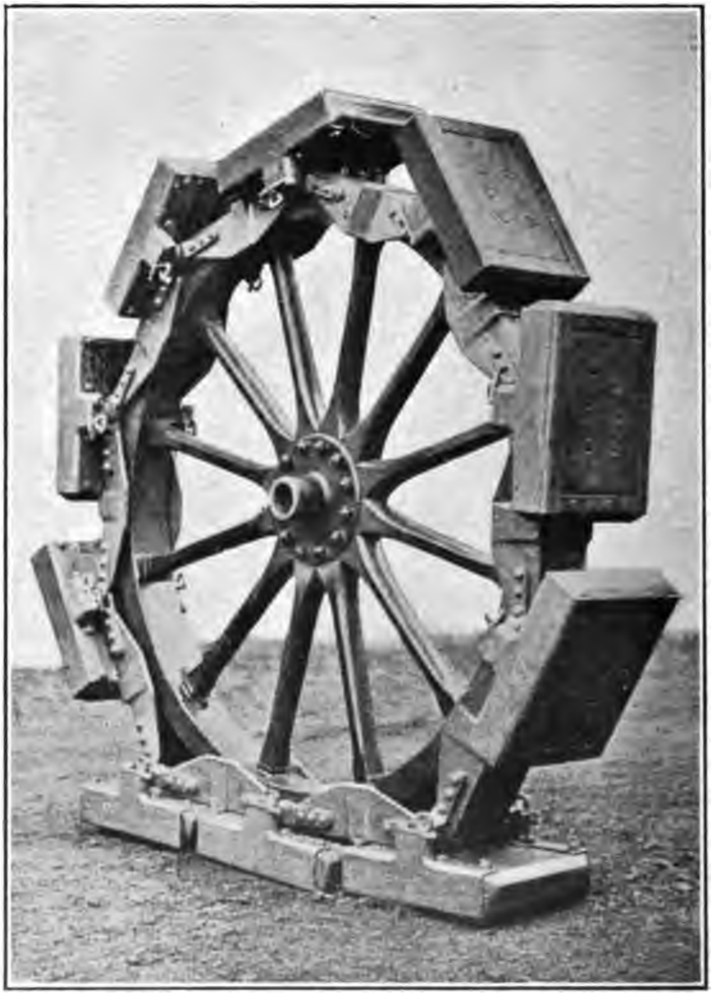


KRUPP 28-CM. (11.2-INCH) HOWITZER ON TRANSPORTING WAGON. 1534

KRUPP 28-CM. (11.2-INCH) HOWITZER ON TRANSPORTING WAGON. 1535

The 11.2-in. Howitzer

The particulars of the 11.2" Krupp howitzer are given below, and the method of transporting it is shown in the Plates. The howitzer travels on a special wagon: the cradle is converted into a carriage by putting a pair of wheels on the cradle trunnions, which are central; and the trail and wheels form a third carriage. 4½ girdles, weighing ½ ton each, travel, when not

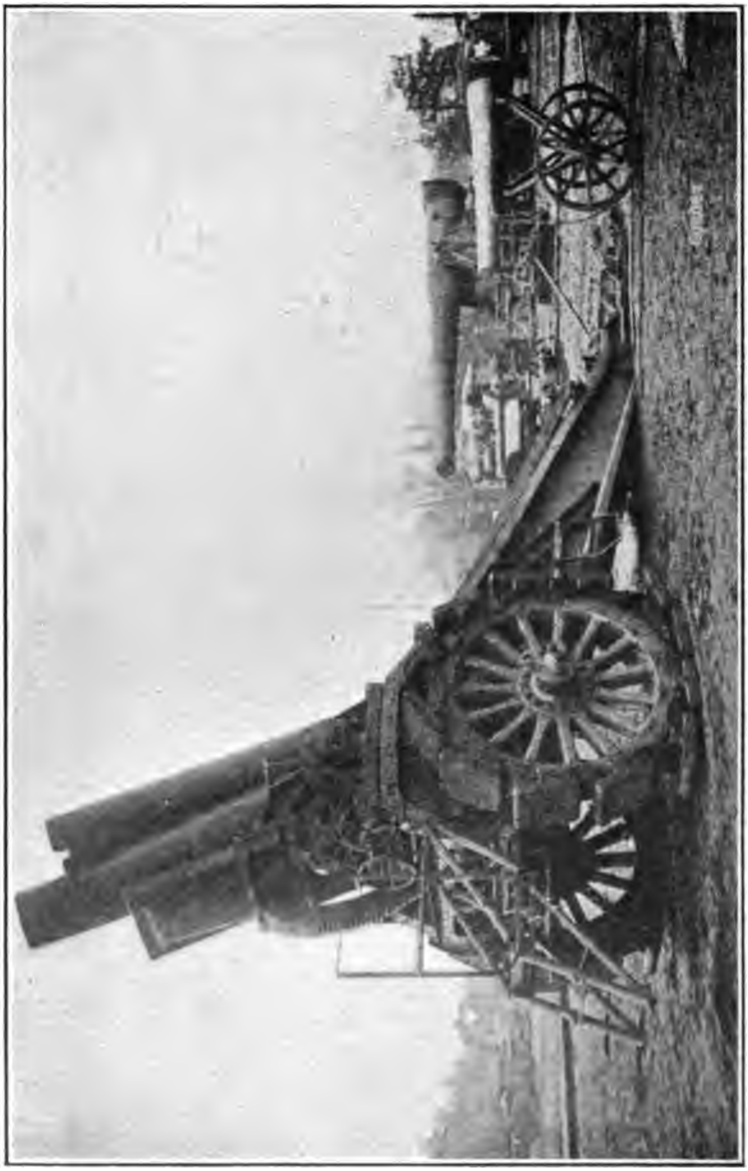


Krupp Girdle for 4.7-Inch Gun 15346

in use, on a girdle wagon, weighing 4 tons gross. The sights, spare parts, and small stores travel on an ordinary motor lorry and the ammunition, packed in boxes and metal-lined cases, is also transported on motor lorries. When in action the ammunition is brought up to the howitzer on a hand cart, as shown in the Plate.

1337

KRUPP 28-CM. (11.2-INCH) HOWITZER.
Shift from transporting wagon to firing carriage.



KRUPP 11.2-INCH SIEGE AND FIELD HOWITZER. LOADING TRAY. 1536

There are several original features about this howitzer. The unusual length of recoil, namely 5 feet, reduces the stress on the carriage so that the howitzer can be fired from its wheels, which are prevented from sinking into the ground by the girdles, or linked steel plates surrounding the wheels. Double mats of woven cane, with steel plates between them, can be used under the wheels to give additional support.

The high elevation, namely 65°, of which the howitzer is capable is intended to allow it to be fired with full charge at short ranges, so as to obtain a high remaining velocity and steep angle of descent. It is presumably considered that the 760-lb. shell will not be greatly affected by wind.

The particulars are as follows:—

Details of the Krupp 28-cm. (11.2") and 21-cm. (8.4") Howitzers

	28-cm.	21-cm.
Caliber, inches	11.2	8.4
Length, calibers	12	12
Position of trunnions	Central.	Rear.
Weight of howitzer & breech action, tons	6.3	2.2
Weight of recoiling parts, tons	6.4	2.3
Rifling, twist in calibers	1 in 50 to 1 in 25.	
Breech action	Wedge.	
Position of recoil gear	Over gun.	
Running up gear	Compressed air.	
Spade	Folding.	
Sights	Independent line of sight.	
Recoil	Constant.	
Length of recoil at full elevation, feet	6	4
Track, feet	7	5½
Diameter of wheels, feet	5' 4"	4' 8"
Width of tire, inches	6.3	4.7
Length of trail, spade to wheels, feet	15'	10' 4"
Shield	None.	Yes.
Maximum elevation, degrees	+65	+60
Minimum elevation, degrees	+30	+20
Traverse, degrees	4	4
Weight in action with girdles, tons	14.8	6
Weight of pair of girdles, ton	1	¾
Pressure of trail on ground, cwt	10	4
Weight of limber, no ammunition, cwt	5.4	7.8
Weight of gun-wagon, tons	1.7	1.05
Weight of gun-wagon limber, tons	0.27	0.39
Weight of one pair girdles, tons	1	¾
Total weight of gun-wagon, loaded, tons	9.27	4.39
Ammunition		
Weight of shell, lbs	760	249
Weight of burster, mine shell, lbs	114	37.4
Weight of burster, thick-walled shell, lbs	38	12.5
Weight of metal cartridge case, lbs	65	21.6
Whether shrapnel fired	No.	No.

Ballistics

	28-cm.	21-cm.
Muzzle velocity full charge, f.s.	1100	1083
Remaining velocity at 2000 meters f.s.	1038	977
Remaining velocity at 4000 meters f.s.	1004	910
Remaining velocity at 6000 meters f.s.	978	877
Remaining velocity at 8000 meters f.s.	966	853
Range at 43° elevation, yards	10,900	8,900

Next as to the possibility of transporting similar howitzers, of larger caliber, by land.

In the first place there is no difficulty about transporting a 16.8" howitzer, weighing 21.3 tons net (see Table above) by rail. In England we have transported the Elswick 100-ton gun by rail. The difficulty as regards road transport is, first, the hauling power of the tractor, and, second, the limit of weight which road bridges will carry. As regards the first, there is no insuperable difficulty; a full-sized traction engine will pull three six-ton trucks, weighing altogether some 30 tons gross, on a level road, and if two traction engines or motor tractors be hooked in tandem, with 20 yards of wire rope between them, a still heavier load can be hauled. Hills are surmounted with the winding gear. It must be said that the 30-ton load referred to above is on six pairs of wheels, whereas the howitzer, if transported as in the Plate, rests almost entirely upon two wheels, which would considerably increase the draught: however it may be considered not impossible, though difficult, to obtain sufficient hauling power to transport a 16.8" howitzer by road.

As regards the strength of bridges, we have some experience in the use of heavy tractors in our own army. Messrs. John I. Thornycroft, whom I have consulted, informed me that in S. Africa we used the "Lion" type of traction engine, weighing 22 tons. They were all sold out of the service when brought back to England, as they were considered too heavy for our roads and bridges. It was found that one of these engines would pull as much as three times its own weight on a good level road.

It would accordingly seem probable that the load of 31.3 tons referred to above as the heaviest component of a 16.8" howitzer cannot be transported on ordinary roads, but it is possible that by keeping strictly to the main "National" roads of France and Belgium, and avoiding all district and communal roads, it may be practicable to find a route upon which the bridges are strong enough for this load. Of course a careful reconnaissance of the bridges would have been made beforehand in time of peace.

As regards the question of firing without a platform:

The 28-cm. howitzer is fired from its wheels, as shown in the Plate. Here the recoil-energy is already 381 foot-tons, absorbed in 5 feet of recoil, giving a stress of 38 tons on each wheel. This is conceivable, but when we come to 1530 foot-tons for the 42-cm., or about 100 tons on each wheel (supposing a recoil of 7.5 feet) this becomes impossible. It would appear therefore that the Krupp howitzers of over 12" caliber must be fired from a bed, that is, from a carriage which has a surface of large area in contact with the soil. Suppose that for the 42-cm. (16.8") howitzer the bed is 15′ × 8′, giving an area of 120 sq. feet, the pressure on the earth on firing will be only $1\frac{2}{3}$ ton per square foot vertically, or 1.83 ton at 65° to the surface, which, though a heavy load, is not prohibitively high for sound dry ground.

However, the Germans do not rely entirely on firing from the ground. Numerous accounts have appeared in the press showing that the Germans surrepititously laid ferro-concrete platforms within range of Belgian and French fortresses before the outbreak of war. Thus the *Matin* states that at Maubeuge Messrs. Krupp, under an alias, purchased in 1911 a piece of land 7000 yards from the fortress, and built platforms of reinforced concrete, ostensibly for a locomotive factory.

Other accounts, from Belgian sources, state that the Germans brought up ferro-concrete platforms in sections for their heavy howitzers, and that these were laid where required and abandoned when done with.

From the account of the *Times* correspondent quoted above, it would appear that the bed is divided into two loads for the heaviest type of Krupp howitzer, reputed to be of 16.8″ caliber. This is possible, but no information is at present available as to how the bed is divided.

The weight of the 16.8″ shell, which is presumably well over a ton (see Table [p. 342]) is another factor which militates against belief in the existence of this howitzer. However, there would appear to be no insuperable difficulty in hoisting and loading a shell of this weight into the chamber, with proper mechanical appliances. The difficulty would rather be to keep it from slipping back at 65° elevation, and even this might be overcome by the use of a cartridge case of sufficient strength. It may be noted that Messrs. Krupp invariably use full-length brass cartridge cases (see details given above) even for the largest calibers.

Heavy Howitzers in the Field

Reliable reports from the front state that the Germans have a considerable number of heavy howitzers in their position on the Aisne. A blind shell from one of these howitzers was dug up; it proved to be 8.4″ in diameter and 4 calibers long, weighing 252 lbs. This is the shell of the Krupp 21-cm. siege howitzer. This weapon is of similar construction to the 28-cm. howitzer described above, and is transported in the same manner. The details are given above.

The shell fired at our troops on the Aisne were mine shell; these penetrate into the ground before bursting, and form a huge crater, from which a column of black dust is projected into the air. These shell are comparatively ineffective against troops at a distance of a few yards from the burst, and our men, who have grown familiar with them, call them "Jack Johnsons" or "Black Marias."

The Krupp Trench Howitzer

A weapon of a different type from the monster howitzers described above is the Krupp trench howitzer shown in the plates. This piece, though light enough to be wheeled by two men, throws a shell weighing 187 lbs. The spherical shell has a loose stem which is loaded into the bore, and which drops out in flight. It ranges about 350 yards at 43° elevation, and the range is reduced when required by increasing the elevation.

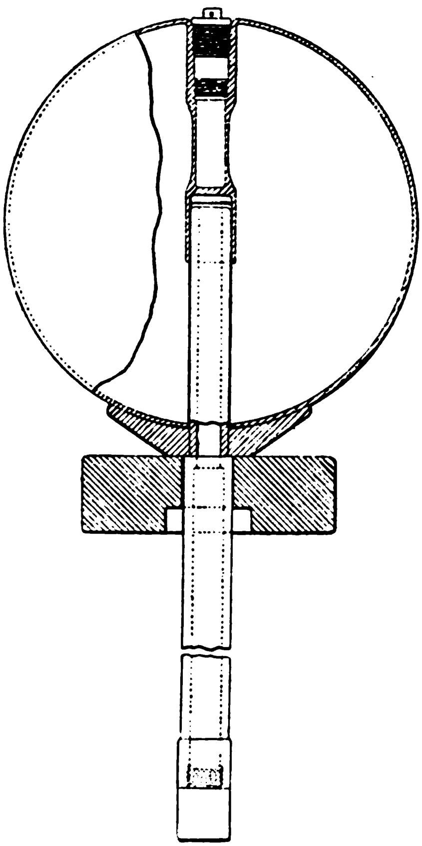
The details are as follows:—

Weight of howitzer, lbs.	128
Weight of bed, lbs.	928
Weight complete on wheels	1160

KRUPP TRENCH HOWITZER ON WHEELS. 1539

KRUPP TRENCH HOWITZER. 1540

Track, inches	32
Maximum elevation, degrees	80
Minimum elevation, degrees	43
Weight of shell, lbs	187
Muzzle velocity, f.s	200



185-Lb. Shell for Krupp Trench Howitzer.

The shell is a thin-walled mine shell containing a large charge, and is intended to act by explosive effect, not splinter effect. Salvos of these shells are to be dropped into an enemy's work just before the assault. The accuracy at 350 yards is said to be very good.

—*The Journal of The Royal Artillery.*

♣ ♣ ♣

THE INFLUENCE OF NATIONAL POLICIES ON SHIPS' DESIGN.*

By Captain W. L. RODGERS, U. S. NAVY.

It is not unusual for people to assume that a carefully designed, well-built man-of-war is a stock article, as good for one navy looking for ships as for another.

This not only is not true, but it has never been true at any period. If we go to our histories we shall see a constant progress and development in the types of men-of-war, and that different nations at the same date have had navies composed of ships of types which they have inherited from their past political and their geographic affiliations.

As an early example we may refer to the campaign of Actium in 31 B. C., between the levantine fleet of Antony and Cleopatra and the Roman fleet of Octavius Cæsar. The civil wars of the previous half century had permitted the development in the central and western Mediterranean of great numbers of pirates who interfered with Roman commerce. About ten years before Actium, Octavius established a strong fleet to put down the pirates and ensure the Roman commerce. This fleet he placed under the command of a very great Admiral, Marcus Vipsanius Agrippa, who was also a great naval administrator. For the police of the seas, which was the pressing political need of the day, Agrippa developed a new type (of men-of-war) known as liburnæ, specially designed for the pursuit of small groups of piratical craft. These vessels were swift and lightly built; their crews fought with slings, javelins and bows and arrows. In a few years with these ships designed for the purpose, Agrippa suppressed piracy. When the strife between Octavius and Antony broke out, it was with the fleet designed for the police of the seas that Agrippa had to encounter a real battle fleet.

On the other hand, the levantine fleet was composed of the contingent squadrons of the vassal kingdoms acknowledging Antony's supremacy. These contingent squadrons were the fruit of over three centuries of development of the invention of mechanical artillery. They represented the efforts of wealthy and organized governments to maintain rival great fleets for the furtherance of strictly political objectives.

Previous to the invention of mechanical artillery in the early part of the fourth century B. C., the chief naval weapon was the ram, and ships were swift and light to maneuver to advantage. The rowers could spurt them to about 7 miles an hour. But the addition of the mechanical artillery to their weapons led to gradual increase in size and weight, and as the motive force depended on the number of rowers who could be placed along the side of the ships, the speed and handiness fell off proportionately. Besides, the scantlings were increased to stand the impact of heavy projectiles (two to three hundredweight).

Thus at Actium the opposing fleets were of totally distinct types of ships; one with heavy artillery, with stout sides, and consequently slow and unhandy, yet possessing as a survival those rams which had been the dominant weapon of three hundred years before; the other with swift, light ships, without rams, depending on hand missiles. The result of the battle was favorable to the Roman fleet of light ships. Rome became the sole political power on the shores of the Mediterranean. The disappearance of rivals reduced the

* Read at the twenty-first general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 11 and 12, 1913.

Roman navy to a police force and caused artillery to disappear from the seas until gunpowder brought it back in a modified form over a thousand years later.

The Roman fleet at Actium was the outcome of political conditions which the fleet itself had ended. That it was successful was owing to the marvelous tactical skill of Agrippa, who had the supreme art to fuse the use of the newest warlike inventions so thoroughly into his scheme of tactics that they were an integral part of the victory. There is a touch of modernity about Agrippa's whole conduct. On the levantine side, the vassal powers of Antony were rich and unprogressive, and their fleets, too, were the product of past international relations, but they did not have the good fortune to be led by a man who could adapt his poor tools to the conditions confronting him.

Passing on for 1600 years to the campaign of the Spanish Armada in 1588 we shall see the same control of ship design by national policies.

On the Spanish side, that nation for centuries had been closely related to Italy and to Mediterranean affairs. Her fleet had developed with a view to maintaining her position there; it had formed a contingent of the Chri tian forces at Lepanto only seventeen years before, and the men who had distinguished themselves at Lepanto were now in command in the English campaign.

The Mediterranean policy of Spain had given her a fleet suited to Mediterranean waters. It consisted of galleys, long, rowing craft, poor sea boats, built chiefly to use the ram and to board the enemy, but equipped with artillery as an auxiliary weapon. Spain also had another and more recent national policy; namely, the exploitation and development of her American discoveries and conquests. The annexation of Portugal only four years before had added greatly to these transatlantic provinces, as well as to the fleets of Spain. The over-sea navy of Spain was of quite another type from her Mediterranean navy. It was composed of galleons, a type of sailing ship having great beam for its length, fitted for cargo carrying, and armed more for protection against pirates than for use in the line of battle.

The Spanish nation was rich, self-satisfied and conservative. Neither the Mediterranean fleet nor the ocean fleet was advancing in material. The leaders were content to believe that the tactics which had brought success against the Turks would do so against the English. Accordingly, when the rising commerce of England began to compete with that of Spain and attacks of Drake and other great English seamen had driven Spain beyond endurance, it was with the somewhat unsuitable types of Portuguese ships, reinforced by a few of the largest and finest of the Mediterranean galleys, totally unsuited to an ocean campaign, that Spain set out for the English Channel.

On the opposing side all was different. England was just beginning to rise in maritime commerce. Everything was progressive, for she felt the need of struggling to force herself into "a place in the sun." Unlike Spain, she had only one field of effort, the ocean; her ships were designed to overcome the Spanish ships; they were faster, new inventions permitted them to sail closer to the wind, and they carried their heavy long-range batteries on the broadside.

The English leaders were prepared to use their ships to the best advantage. They had fought the Spanish before and they knew that the latter were resting on their past achievements, seeking no improvement.

At last the Spanish fleet appeared in the Channel with ships of two different types originally designed to support the two national policies of Spain, with leaders wedded to the ram tactics of the smooth Mediterranean, and the fleet in line, in the ramming formation. The English met the attack with a homogeneous fleet of a type suited to the English policy, in waters to which the English fleet was adapted. The English tactical formation was column suitable for developing the superiority of the batteries at long range. The victory fell to the side which deserved it through the singleness of purpose reflected both in the design of the ships and in the tactics of the admirals.

Again we must notice how the design of the ships is the issue of respective national policies. The national spirit led Spain to unprogressiveness, and England to every improvement in material, whose use the leaders thoroughly incorporated in their tactical schemes. A far-sighted policy supported the genius of England's admirals.

Passing over another three centuries we come to our own Civil War. The outbreak occurred at the period of transition from sails to steam as motive power, and when iron was beginning to replace wood in the construction of vessels. The United States had few ships of any sort. The Federal Government at once embraced the national policy of throttling the commercial life of the Confederacy by a maritime blockade while armies occupied the insurgent territory. Every sort of ship was seized upon to execute this policy, but a chief part fell to the monitors. In these ships Ericsson's invention of the revolving gun turret was mounted on a ship design suitable to the blockade of the shallow waters and sandy coasts of the Southern States. The development was entirely suited to its purpose, but the close of the war found the country in possession of a fleet suited to peculiar conditions, the outcome of a pre-existing political situation.

The country at large, and indeed the Navy, took little heed of the special maritime features of the war, and like the Spaniards after Lepanto, concluded that the ships which had given satisfaction once, necessarily would do so again. So the country settled itself to internal development and to repairing the ravages of the war. No one suggested that the Navy was unprogressive in keeping only the old monitors ready for use. Congress and the Navy Department remained under the influence of officers who had served in the Civil War and whose thought and reflection were limited to that war. Accordingly, when the Spanish war broke out, although it opened new policies and new theaters of action to the country, the effect of these was not understood, and that very summer of the war Congress authorized the last monitors obsolete before they were commenced.

But fortunately the country already had started on the proper plan of designing ships to suit the national policy, although it was done with hesitation and false steps which are not without interest to us in this study.

As the wooden ships of the Civil War became worn out, the Congress authorized in 1882 the adoption of steel vessels; the first of these were small cruisers whose purpose was chiefly to continue the police work of the navy in time of peace, particularly in countries with unstable governments. The designing and building of these ships served to educate our naval architects and shipyards in steel construction. Indeed the plans of several of the earlier ones were purchased abroad and in others we imitated foreign models without any thought that designs suitable to another country's necessities did not perforce suit ours.

One of the most instructive of these misfit designs was that of the *New York*, to understand which we must go far afield and begin with a consideration of the international relations of France and Great Britain in the eighties of the last century.

At this time the relations of those powers were not as cordial as they now are; Germany had not come to the front as the commercial and naval rival of Great Britain so prominently as at present. The fleet of France easily led those of the other countries of the Continent of Europe, and was second only to that of England. The two navies looked at each other as probable and formidable adversaries.

While the French navy recognized its inferiority to the British in combatant strength, its strategic studies led it to believe that it might very seriously embarrass and even distress Great Britain by intercepting the latter's seaborne commerce.

With this purpose in view the French Government of the day laid down a number of commerce destroyers of the type of the *Tage* and *Cecille;* swift ships lightly armed, to act from French ports against the hostile shipping in the neighborhood of the British Isles.

The British replied a year or two later with the *Blake* and *Blenheim*, somewhat larger, faster and more heavily armed and protected to act as commerce protectors—to chase the French commerce destroyers from the seas.

Here on both sides we have national policy legitimately controlling ship design.

The American Congress at this time was desirous in a general way of building up the navy, but the Navy Department had no idea of coordinating the building program with the national policy which was then as now "America for the Americans." This policy called for a fleet capable of maintaining the control of American seas against possible transatlantic enemies. Consequently, the Department, in selecting a design on which to spend the appropriation of the year, considered that the Blenheim type was about the best that it could see for the Navy and proceeded to attempt to improve on it. The result was the *New York*, a very fine ship from the shipbuilder's point of view, but a misfit from the national point of view, because she was a commerce protector. The United States had no ocean commerce to be protected. The *New York* was a very superior British craft, but a poor American one. A year or two later, the Navy Department in its search for ship design, and apparently with the wish to have every sort of tool in its kit, produced two ships of the French type, the *Columbia* and *Minneapolis*. As in the case of the *New York*, there were no ships of the type superior to these "Pirates," as they were called, yet they also were misfits for America. Owing to America's lack of coaling stations and general inferiority in naval power there was no probability that these ships could accomplish anything serious against hostile commerce.

But at this same time the report of the so-called "Endicott Board" on coast defense, made in 1886 and based on a full consideration of national requirements, had borne fruit. The first of our present battleship fleet was already begun. In these ships national policies controlled the design and we have continued to develop this type.

It may be interesting to show the method which the Navy Department now follows in order to check aberrations of ship design which may result in

excellent specimens of naval architecture unsuited to the needs of the country. All the great powers take steps with the same purpose of controlling naval design to suit policy.

The close of the Spanish war showed that the organization of the Navy Department was very incomplete in that it was not based upon the requirements of war, but upon those of the routine of peace, and further, the various branches of the Department were semi-independent and did not coordinate with each other as they should even for the daily demands of administration in times of peace. Moreover, the existing branches of the Navy Department were wholly absorbed in their own administrative duties, and so were unable to take a wide outlook upon naval affairs in general and their relation to the country at large.

As a partial remedy for this condition the Secretary of the Navy established a board of officers of high rank sitting permanently in Washington which was named the "General Board," whose duties were to be entirely non-administrative, but which were to study, deliberate and report upon all large questions of naval policy as derived from national policy, so that this board could indicate the general direction of naval effort, leaving all details of execution to the administrative bureaus responsible therefor.

Among other duties assigned to the Board by the Navy Regulations is that of studying the naval policies of other countries for comparison with our own and recommending numbers and types of ships which the Navy needs in order to be able to maintain our national policies in the face of opposition. A further duty of the Board is to study and report upon the military characteristics desirable in the various types of ships it recommends.

By military characteristics is meant the broad features of offensive and defensive strength, speed, radius of action, etc., etc. The technical means taken in the construction of the ship to assure these military characteristics are beyond the purview of the General Board. Thus the General Board would recommend the proper speed for a scout cruiser, but it would not consider at any stage of the design whether the proposed horse-power was sufficient to obtain that speed.

Nevertheless, when the General Board considers a new type of ship and the military characteristics which it should possess, the Board keeps itself in communication with the constructive bureaus so that its recommendations shall not outrun practical possibilities of the day.

In this way, the shipbuilding program of the Navy for the last few years has had a unity and a consistency from year to year which was previously lacking because no agency existed in the Navy Department for directing the skill of the technical bureaus to meet the particular strategic and tactical requirements which the national policies are likely to thrust upon the Navy in time of war.

Turning towards other nations, we shall find that they all take means to cause ship designs to harmonize with the national policy.

Taking Germany as an example, it is apparent that the last forty years have been marked by a great development of manufactures and of foreign commerce, and the country has felt the increasing necessity of obtaining foreign markets.

Coincident with the development of these commercial projects has been the rise of the German navy. The Emperor embodied the national belief in his phrase "Our future lies on the water."

If now we compare year by year the ships of the German navy with contemporary ones of other powers, we shall be struck with the gradual modification of German types relatively to those of other powers to accord with the increasing field of German commerce and the increase of the relative strength of the German navy as it thrusts itself to the front in the race for naval supremacy. This change in the relation of the German national type to others is expressed in the increase in the calibers of guns and still more in the increasing fuel endurance of German ships. From a small navy for local defense it has been forced to become a great navy of offense, to extend and protect German commerce and German markets. The regularity of this development of general type and the harmony always existing between the characteristics of different contemporary types show the controlling influence in Germany of national policies upon naval ship design.

The conclusion seems manifest that just as in the business world the managing shipowner prescribes to the naval architect the qualities which his ship must possess in order to fulfil the conditions of the trade, so in navies, the products of the naval architect's draughting room must be in accord with the views of accredited expositors of national policies. These expositors of national policies must communicate to those responsible for the design and development of armies and navies the trend of policies in order that national armed forces may ever be suitable and adequate supports of national policies.

But in our country to-day the bond and intercourse between the statesmen who guide our national policies and the War and Navy Departments which may be called upon to enforce those policies are neither as close as they are in other great powers nor as they should be with us.

—*Transactions of the Society of Naval Architects and Marine Engineers.*

THE AUTOMOBILE TORPEDO*

The History of the Development of a Remarkable Invention

For a long time the cannon was the main fighting arm for ships. During the last quarter of the last century the struggle for supremacy between it and increasing efficiency in armor was the reason for such improvement that it is to-day at the highest point of perfection it is likely to attain.

But about 1870 there appeared another naval weapon, the self-propelling torpedo, invented and constructed by Whitehead. This showed its potential power during the war between Chile and Peru (1877), but nevertheless, it was only a weak weapon. The diameter of the early torpedo was 13 inches, its weight not far from 400 pounds, and it carried a charge of explosives of only 35 pounds. Its striking distance was limited to 200 meters (656 feet) and its greatest speed in the water was about 8 knots.

The genial inventor of this weapon was born at Bolton-le-Moors, England, January 3rd, 1823. At fourteen he quit school to become an apprentice in a mill in Manchester, where his uncle was superintendent. At twenty-one he was a draughtsman at Marseilles, and three years later he went to Milan, where his occupation was with silk looms. Here he patented a number of important inventions in machinery for weaving. He was next

* Compiled from *La Nature* and *La Science et la Vie.*

director of the Stabilmento Tecnico, at Trieste, and in 1858 he helped establish at Fiume, not far distant, a marine engineering works which prospered. Of this he became proprietor in 1872, and changed it into a factory for the construction of torpedoes.

The story of the evolution of the Whitehead torpedo is this: In 1860 Capt. Luppis of the Austrian navy conceived the idea of a vessel for coast defense, dirigible from a distance and carrying a charge which when the boat struck a ship or an obstacle would be exploded. In 1864 Whitehead and Luppis associated themselves for the purpose of developing the idea. It was very soon found to be impracticable, but Whitehead thought that the dirigible boat might be changed into a submarine projectile capable of making its own way when launched into the water. The first torpedo was constructed in October, 1866, and despite numerous and important improvements, it was considered even up to the opening of the Russo-Japanese war a weapon of uncertain value. Since that date, however, the opinion of experts has been changed. The first experiments showed that the essential quality to develop was speed, and the efforts were largely along that line for a time. Then on account of the continually greater resistances of the armor of ships it was necessary to increase the explosive charge. Then the development of rapid-fire guns made it more difficult for the torpedoboats to approach their adversaries and greater radius of action was necessary in the torpedoes themselves. The different demands led to gradual increase in the caliber of the projectile, but here the question of weight came as a determining factor. It is necessary not to exceed the weight or dimensions that can easily be handled on shipboard. Next there was the use of compressed air for motive power. It has been through the combination of all these factors by dint of an enormous amount of ingenious invention and adaptation that the modern torpedo has been possible.

The following specifications, compiled from various statements will serve to outline the development of the torpedo.

Model of	Diameter. mm.	Weight. kg.	Speed. knots.	Range. meters.	Charge. kg.
1868	331	180	6–8	200	18
1889	381	432	22	1,500	75
1892	450	...	25	2,000	94
1906	450	650	40	3,000	100
1912	450–533	900	45–48	6,000	136

The model of 1906 was the turning place which made the torpedo a real rival of the cannon. The speed was raised to 40 knots, and the distance possible to 3000 meters (more than a mile and three quarters). The caliber remained constant, but the projectile was lengthened and new machinery introduced which increased the weight. The type of 1912 shows still further advances, and a range of nearly four miles, but the weight limits its use to vessels of larger, modern dimensions.

Everywhere skilled men have been working for the perfection of the torpedo, and the processes of improvement are everywhere evident, notably in the machinery. By employing larger reservoirs of compressed air the range of its action has increased even up to 10,000 meters. On the other hand it is necessary to travel this distance with such speed that the vessel against which it is aimed cannot run away or maneuver so as to avoid it. One of the

processes tending to increased efficiency is the heating of the air. This has been an important step, carrying the solution to grave difficulties, among them the problem of lubrication. Compressed air when liberated is an excellent refrigerant, and it has been found that the temperature of the exhaust is frequently below zero Cent. Such cold produces annoying troubles in freezing the lubricants in a machine which must employ them everywhere, and the high temperature of the air modifies this difficulty.

Various systems are employed for heating the air for torpedo engines. The usual method employed is by burning alcohol either within the air reservoir or in the pipes leading to the motors. The illustration (Fig. 4) shows the device (*SH*) within the tank of compressed air. The advantage of heating the air is shown by the following table of comparison. The speeds are given for different distances from the firing station, the torpedoes actuated by heated air not only attaining a higher early velocity (almost one quarter greater), but maintaining a higher percentage of it through a long run (65 per cent against 57).

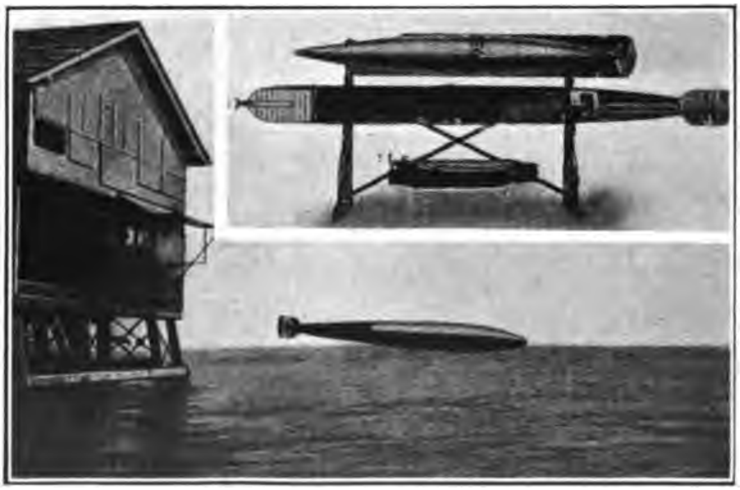


FIG. 1. 1542
LAUNCHING TRIAL TORPEDO
Insert: 1, the first torpedo; 2, torpedo of to-day; 3, dirigible boat of Luppis.

Distance.	Speed with cold air.	Speed with heated air.
1,000 meters	35 knots	43 knots
1,500 meters	30 knots	40 knots
2,000 meters	28–25 knots	38 knots
3,000 meters	25–21 knots	32 knots
4,000 meters	18–20 knots	28 knots

Then by another very ingenious device it is possible to give the self-propelling torpedo a trajectory that is effectively rectilinear by furnishing it with a gyroscope governing the rudders. It is possible in this way to keep

the axis of the torpedo to the direction given it on the start. The apparatus was planned by Obry of the Whitehead shops at Fiume, and is generally known by the name of the inventor. At first the motive power to keep the gyroscope in motion was a spring, but this proving irregular a little motor run by compressed air is now used. The original model of Obry had a minute dynamo.

Theoretically, it is merely necessary to aim the torpedo correctly to have it strike the target, but here there are practical difficulties, for both sender and receiver may be in motion, and there is besides the uncertainty that every hunter feels in the presence of game.

A very real improvement in the modern automobile torpedo is that the quantity of explosives has constantly been increased. From the earliest model with about 33 pounds to those in use to-day, which have as much as 300 pounds of gun-cotton, the step is a long one, and the present missile is capable of causing great destruction in the hulls of even the best protected vessels.

It is interesting to note the different lines of development in the various powers of the world with reference to the torpedo.

In France the modifications have led to a type of 450 millimeters with a charge of 108 kilogrammes of gun-cotton, the explosive force of which is four times that of gun-powder. The weight of the projectile is 2600 pounds; the range, 9000 meters, the early velocity 42 knots, which is maintained up to 2000 meters, with the final velocity not less than 28 knots. The price of such a projectile is about $4000. The new French armored ships are furnished with six torpedo tubes below the water-line and protected against direct shots, while the submarines now carry eight tubes.

England uses torpedoes of 533 millimeters caliber of the Armstrong & Hardcastle models, with an early speed of 45 knots and ability to maintain high speed, and the charge is 130 kilogrammes of explosive.

Germany places on board its armored ships a torpedo of 530 millimeters with 128 kilogrammes of explosive, while the cruisers and torpedoboats use another model of 500 millimeters, but with the shorter range of 4000 meters. Studies have been made with torpedoes of 600 millimeters with great speed and range.

Russia is the only power besides France that has kept to the model of 450 millimeters, but with a heavier charge, 125 kilogrammes. The range of the Whiteheads it uses is greater than 6000 meters.

In the United States the model adopted is the Bliss-Leavitt (see illustration) of 533 millimeters diameter with 128 kilogrammes charge, capable of making 36 knots at 1000 meters and 30 knots at 4000 meters. Experiments have been made with others of the projectiles with effective distances up to 9500 meters.

As to modern tactics with these terrible weapons, it consists no longer of isolated shots, but in volley fires. Such a discharge of a number of torpedoes against a line of ships is considered as sure of results. The torpedoboats under such circumstances will have some advantages, for after the first phases of a naval combat a certain amount of confusion is likely to be produced by some of the vessels showing signs of weakness, and then they can charge the fleet in a body. This may take them to within 2000 or 3000 meters of the enemy, and without doubt they can from there send out torpedoes that will be pretty certain to hit.

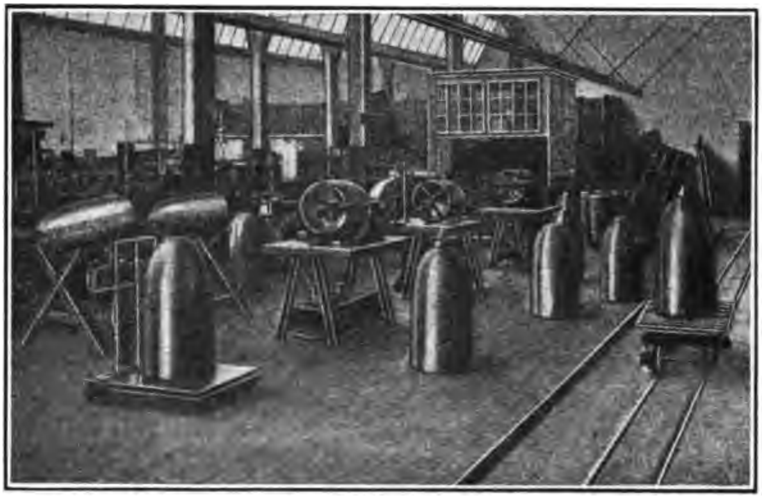


FIG. 2. 1543

TORPEDO-HEAD SHOP

These cones enclose the explosive, and are furnished with percussion needles.

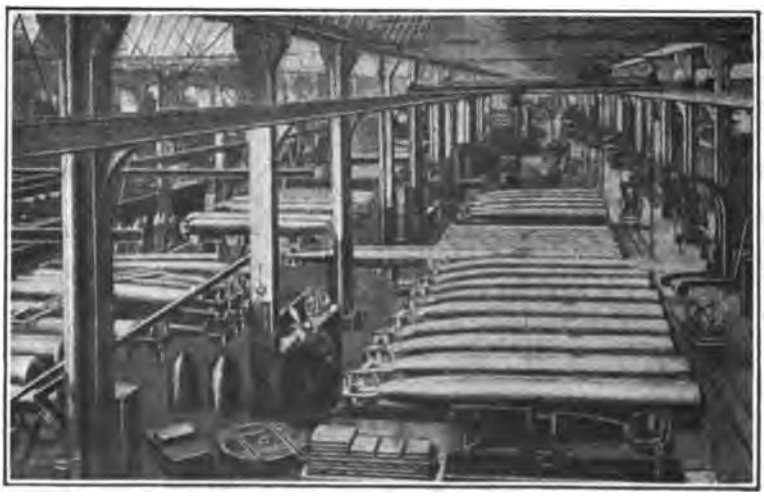


FIG. 3. 1544

TORPEDOES READY FOR DELIVERY

The explosive heads are not affixed until just before they are launched.

Fig. 4.

Section of Bliss-Leavitt Torpedo

P, percussion needle; *G*, safety pin; *C*, explosive; *D*, priming; *B*, compressed air tank; *K*, water valve; *H*, pendulum; *M*, motors; *SH*, air heater; *O*, plunge-motor controlling the depth of immersion; *V*, gyroscope; *T*, gyroscope spring; *GH*, plunge rudders; *FG*, rudder controls; *E*, shaft; *I*, propellers. The steering rudders are the little dark squares in the forward expansion of the tail.

It is generally estimated that at 4000 meters 30 per cent of the torpedoes will be effective. If this were only ten per cent, and out of 40 projectiles 4 explode and put out of the battle two or three vessels, the attacking fleet will have achieved enormous results.

Torpedoes have the general form of a cigar, being about 5 to 6 meters in length with a diameter of about 450 millimeters. The body is of steel, and consists of four sections firmly screwed together. The head, about one eighth of the whole length, is conical in form, and within it is the explosive furnished with the percussion apparatus, which, when the projectile strikes an obstacle, ignites the priming and causes the explosion. Behind this is the second section with the air reservoir, a steel cylinder containing compressed air for the motors and machinery. The third section may be called the engine room, where there are the various devices for propulsion, steering—both laterally and vertically—etc., and behind this a combination of shaft-room and rudder runs. There are two propeller shafts, one within the other, each with its own screw. The propellers are in a kind of cage of square frames, the pattern of which varies in the different torpedoes, which furnish bearings for the propellers and supports for the rudders.

—*Scientific American Supplement.*

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BATTLESHIP PROTECTION AGAINST SUBMARINES

PROPOSED INCREASE OF ARMOR AT THE EXPENSE OF DECREASE IN SPEED

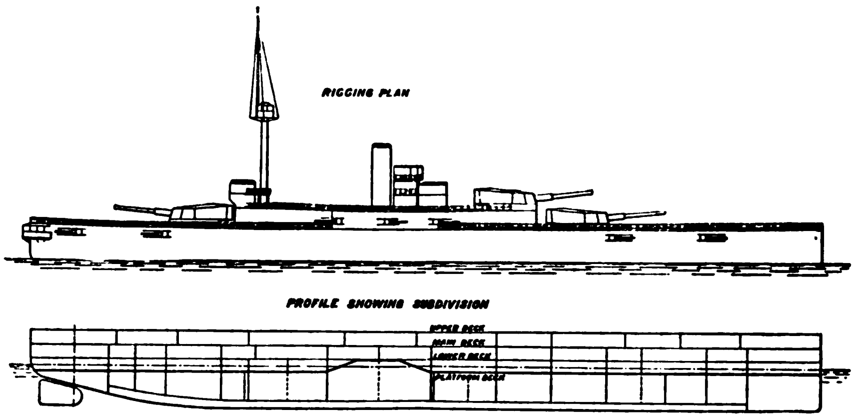
Sir John H. Biles

We are told that the Navy exists to keep the command of the sea, and that command of the sea is necessary for its freedom. To keep the command it is desirable—some say, necessary—to discover and destroy the enemy's forces. Battleships, cruisers, destroyers, submarines, must all be caught and destroyed or captured, and, equally, all must be capable of resisting destruction or capture. In the two dimensions represented by the surface of the sea, with equal powers of vision, getting within destroying distance is a question of speed, and destruction is a matter of superiority of attack over the defense. The dominating weapon of attack has been the gun, and the defense against it has been practically all above water, because there its attack has been made. The torpedoboat and, later, the destroyer, have delivered their main attack below water, but the attacked ship is held to be quite capable of delivering a counter attack by guns above water, which is an adequate reply to the destroyer. The attack of the submarine is wholly below water, and so far the attacked ship has developed no effective reply of its own. The defense against the gun is armor and other guns. The defense against the destroyer's torpedo is the gun, which is quite ineffective against the submarine. The question of interest at the moment is, What defense can the surface ship have against the submarine's torpedo?

There can be only two forms of defense. First, the destruction of the submarine by other vessels, submarine, or others. Second, the protection of the bottom of the surface ships from the effects of under-water attack. The first, the destruction of the submarine, is obviously not the work of a battleship or large cruiser, but must be left to some vessel of the same order

of size as the submarine. This destruction must be sought on the surface when the submarine is not submerged, for it seems improbable that a submarine will be able to chase another effectively under the water. In any case, the submarine will be dangerous to the large surface ship until it is destroyed, and, as the means of destruction are not yet certainly to hand, the question of effectively protecting the battleship against under-water attack seems to be deserving of consideration, unless some one is ready with a real reply to the submarine.

Assuming, as one reasonably may, that very serious damage will be done by the explosion of a torpedo, the next question is, What can be done to prevent or seriously to reduce this damage? Subdivision naturally suggests itself as one means of minimizing the effect of this damage, but when all that is possible in this direction has been done, there seems to be no great certainty that a battleship will be still a formidable fighting machine after having received the successful contact explosion of a 21-inch torpedo. Can we do anything in addition to subdivision to preserve the ship for effective fighting purposes?



Design of a Battleship with Heavy Underwater Armor. 1546

Armor on the bottom of warships has been proposed by responsible persons. The question of the weight of such armor must be serious and obviously the addition of such weight cannot be made without some changes and sacrifices. To some it may seem that the readiest way to approach this problem is to clothe the bottom of a 25,000-ton battleship of the latest pattern with armor, and to increase her fullness sufficiently to allow her to carry this armor, letting everything else remain unaltered. The only considerable effect will be to reduce the speed by two knots.

It is not always that the readiest way of approaching a problem gives the best result. One of the characteristics of our latest battleships is that their forms have a low resistance to forward motion. If a form is produced which is better adapted to fitting and carrying armor, though it may involve greater resistance or less speed, it may on the whole be better to adopt such a form. It may be interesting to give an instance or two of the application of this principle.

A design was produced, the principal elements of which are:—

Length over all	460 ft.
Length between perpendiculars	434 "
Breadth, extreme	80 "
Draught of water	24 "
Displacement in tons	16,000
Speed	18 knots
Armament	sixteen 5-in., six 14-in.

Thickness of armor:—

On side at waterline	5 in.
Above waterline	5 "
Below waterline	4 "
On casemate	2 "
On barbettes	5 "
Thickness of protective deck-plating	2 "

This vessel is of about the displacement of the *Lord Nelson* which is, when purpose serves, called a Dreadnought. The armament is about the same as the first design, but the armor has been reduced so that it will only keep out 6-inch projectiles. This ship may be considered as sufficiently well armored above the waterline. All the sections below the waterline are straight, with a circular arc at the end. This form has been adopted to simplify the armor construction of the bottom. It is fully recognized that such a design outrages the convictions of economists, because ships of such size do not produce the greatest number of guns for a given expenditure. But if we are to be subjected to the ready loss of ships by submarines we may have to be prepared to sacrifice some gun power for our expenditure, and get our recompense in the greater number of ships and guns remaining afloat after the submarine has done its work.

With a view to enabling those who do not believe in reducing the upper armor of a ship, nor in such a low speed as 18 knots, design has been considered in which the bottom is armored, and is of similar form, but in which the speed, armor and armament are of the same order as the Dreadnoughts. Such a vessel could take her place in the First or Second Battle Squadron, and would have armored protection against torpedoes. The principal elements are as follows:—

Length over all	600 ft.
Length between perpendiculars	570 "
Breadth, extreme	91 "
Draught of water	28 ft. 6 in.
Displacement in tons	28,500
Speed	21 knots
Armament	sixteen 6-in., ten 14-in.

Thickness of armor:—

On side at waterline	10 in.
Above waterline	7 in. and 5 in.
Below waterline	4 in.
On casemate	2 "
On barbettes	12 "
Thickness of protected deck-plating	3 "

—*The Engineering Magazine.*

PROJECTILE PHOTOGRAPHY

EASILY ARRANGED APPARATUS FOR STUDYING THE FLIGHT OF BULLETS

By Norman Barden

Nearly all of the fascinating work of photographing projectiles in flight has been done in large laboratories, and those interested in this subject have felt that they had not the required apparatus for such experiments. Now the purpose of this article is to set aside these ideas and to give a clear idea of the whole operation. It may well be said that any student attending a school or college possessing a physics laboratory can succeed in obtaining good negatives of projectiles in flight. As a rule the most serious drawback is the lack of an induction machine, but it is quite possible to use an induction coil in its stead. In the following lines a description and explanation of the complete operation as carried out by the writer in the physics laboratories of the East High School of Minneapolis, Minn., will be given.

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Arrangement on the Apparatus for Photographing a Bullet in Flight.

The apparatus used in this method of photographing projectiles in flight consisted of an induction machine, a battery of Leyden jars, a spark gap, large condensing lens and a camera. A view of the complete apparatus arranged in a working condition is shown herewith. At the extreme right will be seen the gun clamped rigidly to the table. Placed on the table to the left and back of the gun is the induction machine. Just to the left of the static electric machine is the battery of Leyden jars. Then further to the left is the spark gap, directly in front of which are the condensing lens and camera respectively. The framework which shows near the Leyden jars is a device for holding two wires by means of which the spark is caused to jump at the spark gap by the bringing of the two wires referred to in contact with one another. The whole operation is carried on in a perfectly dark room save for a dim ruby light. The arrangement of the apparatus is clearly shown in the accompanying diagram.

The arrangement of the apparatus is as follows: The gun is first clamped tightly in a rigid position. Then a target for stopping the bullet is put in position. A target can be made either of blocks of wood or by tying several thick magazines together. Before arranging the rest of the apparatus the

path of the bullet must be found. This is done by placing two pieces of cardboard in vertical positions in the apparent path of the bullet. Put one about a foot in front of the muzzle of the gun and the other a foot to the far side of the point where the camera is to be placed. A shot is now fired, puncturing each cardboard. Now by sighting through one hole in the cardboard to the hole in the other, the path of the bullet may be located to a nicety. The next piece of apparatus to be set up is the framework for holding the contact wires or strips in the path of the bullet. The contact wires are placed vertically and must be exactly in the path of the bullet. For the contact wires or strips No. 36 copper wire or leaf copper wire will serve the purpose very well. Having put the framework in the proper position proceed to place the spark gap and the condensing lens and camera in their positions. There can be given no definite measurements for the placing of the last named pieces of apparatus, as different experimenters will probably have different kinds of instruments. However, it is best to place the condensing lens, which should be five or six inches in diameter, about two inches from the path of the bullet. Set it on the side on which the camera is

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THE BULLET EMERGING FROM THE MUZZLE. NOTE THE SMOKE PRECEDING THE BULLET.

to be located. A condensing lens having a focal length of about six inches will be found to be very well suited for the purpose. Now put the spark gap at such a distance from the lens that the pencil of rays converging from the lens will be brought to a focus at about eighteen inches from the path of the bullet. Then place the camera so that its lens is at the focus of the pencil of rays just referred to. The camera should be focussed on the path of the bullet in order to get a sharp image of the projectile. The optical axis of the camera ought to be perpendicular to the path of the bullet, and the spark gap placed on this axis; also the axis of the condensing lens should coincide with that of the camera. For a clear idea of the arrangement of these pieces of apparatus consult the diagram. Set the Leyden jars and the induction machine in any convenient position. By following the arrangement in the diagram a great deal of unnecessary wiring and a large amount of electrical leakage which is at times very troublesome will be avoided. Connect the machine with the Leyden jars and the jars in series with the spark gap and the second break, thereby making two breaks in the circuit. For the connecting wires annunciator wire may be used; but it should run from one connection straight to the other. Wherever the wires are to be supported they must be highly insulated. Pieces of glass tubing are very convenient to use. Also wherever a wire might touch anything which might give way to leakage or a short circuit, insulate it with glass tubing or mica. Having

put the apparatus in a working condition proceed to try out the experiment.

First of all see that the contact wires are placed exactly in the path of the bullet, and that they are about a quarter of an inch apart. Bend one wire so that the other will surely come into contact with it. Adjust the spark gap so that the terminals are about a quarter of an inch apart. Now operate the machine until the current jumps through both breaks. Do this several times and look for defects in the wiring. On finding everything all right, stop the machine and fully discharge the Leyden jars. Now find out how many turns of the induction machine handle will charge the jars so that they will discharge through both breaks. Do this several times, discharging the jars between each trial, and find the average number of turns. Now try it again, but this time give it four less turns and then push the contact wires together with a glass rod or other good insulator. If the spark is produced at the spark gap when the contact wires are brought within a sixteenth of an inch of each other, the correct number of turns has been found. Now load the gun and cock it ready for firing, turn the handle of the static machine the correct number of turns and at the last turn fire the gun. At the same time watch the spark gap to see if the spark was produced or not. After having put all the apparatus in a working condition try a plate.

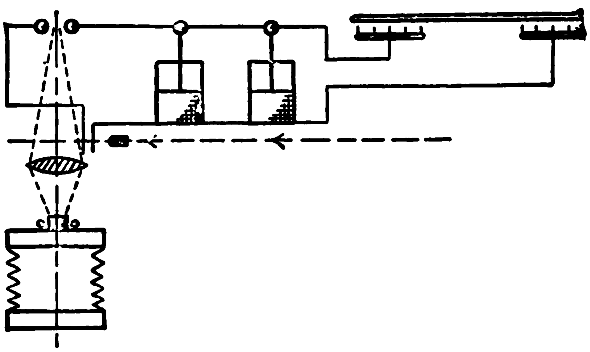

DIAGRAM OF ELECTRICAL CONNECTIONS. 1519

Nothing has been said heretofore regarding the kind or size of plates or the kind of camera to be used. For the camera one with a lens of large aperture is preferable to one of small aperture. However, the lens of almost any camera may be used if the pencil of rays coming from the condensing lens is focused exactly upon the center of the camera lens. For the plates, fast ones are best to use, and the faster the plate the better the picture. The writer used Lumiere Sigma plates with good results. The plates should be large enough to show about four of five inches of the path of the bullet. By consulting the illustrations it will be seen that the contact wires were placed so that they just showed on one side of the plate, thereby leaving the rest of the plate to catch the projectile.

After exposing the plate develop it immediately or in a short time. Use any reliable developer and use a solution of such strength that developing will not have to be carried on for more than five minutes. Fix the plate in a strong acid hypo solution, and let it fix about twice as long as it takes it to clear. Wash the plate thoroughly and dry it in such a position that the dust will not settle upon it. It will be found convenient to make the dark room

in which the experiment is carried on, serve as the photographic dark room. This saves a great deal of time as well as trouble. If the foregoing instructions are followed, the writer feels confident that there will be no great trouble in obtaining good negatives of projectiles in flight. A great deal depends upon the experimenter, and he must depend upon himself to correct some possible defects which might arise from his own methods of wiring and arranging the apparatus. There is still a large amount of knowledge to be gained by this fascinating work, and it is within reach of a great many who do not realize the possibility of their carrying out this experiment.

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THE BULLET IN FLIGHT; MUZZLE VELOCITY, 903 FEET PER SECOND

In one of the illustrations, at the left is seen the muzzle of the gun and the projectile which has just emerged from it. Around the back part of the projectile are seen the jets of expanding gases. The volume of smoke and gas which precedes the bullet from the barrel is shown very plainly. The white streak is the spark between the contact strips. Many interesting and instructive pictures of this sort are in reach of those who follow the foregoing explanations and instructions.

The writer wishes to say that he is greatly indebted to Prof. J. R. Towne of the Department of Physics at the East High School of Minneapolis, Minn., as it was through his kind permission that the use of the laboratories was obtained for carrying out this interesting experiment.

—*Scientific American Supplement.*

INFLUENCE OF VARIOUS TEMPERATURES ON THE PROPERTIES OF ADMIRALTY GUN METAL

By Prof. JOHN G. LONGBOTTOM, A.R.C.S., M.I.Mech.E., and Prof. A. CAMPION, F.I.C., F.C.S.

In their paper read before the Institution of Engineers and Shipbuilders in Scotland, at Newcastle, the authors said that the earliest published results of experiments on the effect of temperature on the mechanical properites of gun metal appear to be those contained in a report of investigations on alloys carried out under the direction of the Admiralty at Portsmouth Dockyard in 1877. Heating of the test bars was effected by means of an oil bath, from

which they were transferred to the testing machine, and broken with as little delay as possible. At the best the results can only be considered as roughly approximate, owing to the variable and uncertain cooling of the specimens during testing.

Two series of gun metal bars of the same composition were tested in tension. In the first series the tensile strength fell from 12.0 tons per sq. in. at atmospheric temperature to 11.2 tons per sq.in. at 300° Fahr. (148.9 C.), while in the second series the fall was from 12.9 to 6.6 tons per sq. in. The corresponding changes of ductility were from 12.5 to 10 in the first series, and from 8.75 to 0.66 in the second series. Great changes in both tenacity and ductility were found in the first series at temperatures from 350° Fahr. (176.7 C.) to 400° F. (204.5 C.) the strength falling from 10.1 to 5.5 tons per sq. in., and the ductility from 8.25 to 0.75.

The authors next enter in their paper upon a long and detailed account with illustrations of the various tests and apparatus employed by them in the course of their researches. For lack of space we are obliged to omit this matter and pass on to an abbreviated account of their deductions.

In testing not only non-ferrous metals, but also steels, at some temperatures, very marked slips occur after the yield point is passed; in some cases these slips are so great that the steelyard of the machine falls on to the bottom stop as if rupture of the specimen has occurred; but after a short time the material stiffens, and carries a further load. A series of such slips, in some cases as many as ten, have been observed between the yield point and the maximum stress of the material. If the load be reduced when one of these slips has taken place, so as to allow the steelyard to rise, it is found that the load may be increased a little beyond that at which the slip occurred before the material again slips. These slips are invariably accompanied by an evolution of heat.

These phenomena were not observed in tests of this material at temperatures above 350° C. They are generally more marked in rolled than in cast material.

In the opinion of the authors this is due to the amorphous cement recrystallizing to such an extent that the adhesion between the crystals of the metal is reduced sufficiently to allow some of the crystals to part from their neighbors under the particular stress. Actual fracture is, however, prevented by the crystal faces rubbing one against the other with considerable pressure, thus reforming a quantity of the amorphous material, with the result that adhesion is partly restored. This material is in turn recrystallized under the influence of heat, and another slip takes place. In this manner there is alternately destruction and restoration of the amorphous material, with corresponding alternate decrease and increase of strength of the material.

Evidence in support of the author's view was obtained in a somewhat unexpected manner. It had been noticed on several occasions during the progress of a test that the temperature suddenly rose several degrees, which in the earlier experiments was attributed to changes of voltage in the heating current. It was, however, observed during the testing of scme steels that this sudden increase in temperature always occurred soon after the elastic limit had been passed. This led the authors to make very close observations during the later tests on the gun metal, which resulted in the interesting discovery that immediately after each of the slips mentioned above, an appreciable increase of temperature of the material occurred. So far as the

authors are aware, this has never before been recorded, although it is what might be expected to result from the recrystallization of the amorphous material.

Ewen and others have shown that plastic deformation of crystalline metals takes place partly by the crystals slipping one over the other, and partly by deformation of the crystal elements themselves.

The crystalline structure of metals has been likened by Rosenhain to a pile of bricks stacked in a regular manner. If this analogy be carried a little further, by considering that each brick, instead of being rigid, is composed of a substance like india-rubber, and that the joints between them are filled with a cement, which itself is stronger than the material of the crystals or bricks, it may be used to illustrate the behavior of metals at high temperatures. As long as the cement retains its strength the application of stress produces deformation, principally by an alteration in shape of the individual crystals; fracture ultimately takes place by a tearing of a portion of the material in contact with the cement, and the material has considerable ductility. If, however, the strength of the cement becomes imparied, the applied stress produces a smaller amount of deformation in the crystals themselves, more slip between the joints, and the ductility of the material is reduced. When the cement is weaker than the material of which the crystals are composed, there is practically no deformation of the crystals, and fracture, which takes place when the ultimate strength of the cement is reached, is due almost entirely to slipping.

The authors consider that the amorphous cement loses its ductility at a lower temperature than [that] at which it loses its strength, and consequently the ductility of the material deteriorates more rapidly than the strength with increasing temperature. The roughened appearance of the surface of the specimen after testing at the lower temperatures, in contradistinction to those tested at high temperatures, lends additional support to these views.

This theory seems to the authors to furnish a complete explanation of the critical points in the ductility curves at 350° C., and of the entire mechanism of failure of the material at various temperatures.

In this research no special precautions have been taken to avoid oxidation, as it was their desire to test the material under, as nearly as possible, the conditions to which it would be subject in practice; but they are thoroughly alive to the fact that oxidation may have an important influence on the behavior of the material at temperatures above that of the atmosphere. It is their intention to make further experiments in a non-oxidising atmosphere.—*Page's Engineering Weekly.*

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OUR NEW BATTLESHIPS

While there may be some new features in the battleships authorized by the last appropriation bill, they will represent no radical departure in construction or equipment. No attempt will be made to increase the speed, despite the agitation along this line in Europe, the naval authorities standing pat on their contentions that to increase the speed of a battleship it would be necessary to sacrifice its offensive or its defensive qualities. Of course, an effort will be made to increase the armor if it can be done without interfering

with the speed of the ship. In order to fit into the organization of the best vessels of the fleet the three new ships must develop a speed of between twenty and a half and twenty-one knots. One of the chief reasons for disposing of the *Mississippi* and *Idaho* was their inability to make this speed. Although the Bureau of Ordnance some time ago prepared plans for a 16-inch gun, which plans can be used at any time the Secretary decides to increase the size of the guns on the battleships, it is not probable that this step will be taken in the construction of this year's program. The new ships will therefore carry the present type of 14-inch guns. This is regarded as one of the most powerful guns afloat, if not of the longest range. Nothing has happened in the construction of the navy of any other country to convince the Navy Department that the time is ripe for an increase in the caliber of the big guns of the Navy. The three-gun turret arrangement having proved a success, this arrangement of the new battleships' armament will be followed. It is doubtful whether the ships could carry three 16-inch guns in one turret, and a change in the size of the gun would make it necessary to make some radical departures in turret construction. Of course, the new ships will be oil burners, and it is understood that they will be propelled by turbine engines. Mr. Daniels signed the contract plans for the new battleships on July 30. They will have a displacement of 32,000 tons, and will be named *California*, *Idaho* and *Mississippi*. Of these new battleships two were provided for in this year's appropriation bill and the third will be paid for by the money obtained by the sale of the old battleships *Mississippi* and *Idaho* to Greece. Bids for the new vessels will be sent out Aug. 1. The bids will be opened at the Navy Department Oct. 6, 1914. The vessels will have turbine engines and oil burning boilers of the water tube type. The dimensions and principal points of the new ships are as follows: Length over all, 624 feet; length between perpendiculars, 600 feet; breadth, extreme, 97 feet 4½ inches; draught, 30 feet; displacement, 32,000 tons; speed, 21 knots. Armament, main battery, twelve 14-inch guns; four submerged torpedo tubes; torpedo defense battery, twenty-two 5-inch rapid-fire guns.—*Army and Navy Journal.*

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EXTRACTS FROM THE BIMONTHLY ORDNANCE REPORT FOR JULY-AUGUST, 1914

THE ORDNANCE BOARD

14-inch gun, model of 1910.—Test completed, satisfactory.

Jump of 3-inch field gun, model of 1902.—Sensibly unaffected by presence or absence of elevating and traversing mechanism.

Extreme range, 12-inch gun with 700-pound projectile.—19,352 yards at 15 degrees elevation.

FRANKFORD ARSENAL

Elevation quadrants.—An order has been received for the manufacture of eight elevation quadrants and eight elevation quadrant supports for use with 12-inch mortar carriage, model of 1896 MIII.

WATERVLIET ARSENAL

Guns manufactured.—

Eight 6-inch howitzers, model of 1908.

Eight 12-inch mortars, model of 1912.
Three 14-inch guns, model of 1910.
Ten 4.7-inch guns, model of 1906.
Eight 4.7-inch howitzers, model of 1912.
Four 3-inch (15-pounder) guns, model of 1903.

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ARTILLERY IN 1693

From *Arms and Explosives* for July, 1914, is taken the following extract from a second edition published in 1693 of a book dealing with M. Vauban's *New Method of Fortifications.*

The extract is from the last chapter and is interesting because of the information it gives as to the power of the weapons used in those days.

"Having given some account of irregular fortification, reserving to ourselves another time to speak more of it; we shall only observe what sort of artillery they have in France. There is 1. The Cannon, which is call'd the Battering Piece. 2. The Colverin. 3. The Falcon. 4. The Saker. 5. The Petard. 6. The small Petard. The Battering Piece is 10 Feet long. The Bullet about six Inches Diameter, and weighs 33 pounds. requiring two pounds of Powder at least, to charge it; and it carries directly forward 360 Fathoms. At the distance of 100 Fathoms, it pierces two Fathoms of clos'd Earth. If it be not well settled, it pierces two fathoms and a half; and if the Earth be poor, and hungry, it pierces four fathoms, You may discharge it eighty times in a day. The Dutch Cannon flings a bullet of 48 pounds, 400 feet distant, and pierces a Rampart of good and well clos'd Earth 20 feet deep. A half Piece of Battery carries a bullet of 24 pounds, at 300 feet distance, and enters twelve feet of good Earth. The Falcon carries a twelve pounder 200 feet off, and enters 7 feet into a good Parapet.

A Small Petard cannot break a double gate well barred. A Great Petard fix'd to a weak Gate, usually makes no more than a Hole; and the greatest execution it can produce, is to break the fore part of it.

There is nothing to stop the Execution of Mines, as they make them at present; nevertheless there must be a Proportion between the Petards, the Mines, etc., and the Powder.

Lastly, a Musquet carries 120 Fathoms, and if double charged 150, through it will kill a man above 300 Paces. Discharged very near it will pierce two Planks two Fingers thick; but discharged at 50 Paces, it enters according to the substance of the Body it meets with. * * *"

—*Arms and Explosives.*

Short Notes

Ever-Increasing Gun Power.—The report that the Germans held in reserve a surprise for the Allies in the shape of a huge gun manufactured by Krupps which was going to make dust of the strongest forts, leads us to examine the wonderful advance that has been made of late years in these death-dealing machines. The possession of these mightiest of mighty guns

is naturally confined to Great Britain, France, Italy, Russia, Germany, and the United States, the largest of them all, reckoned by size of bore and weight of projectile, being, perhaps, oddly enough, an Italian-owned gun, but English made. The diameter of its bore is 17 inches, and when it is remembered that the 6-in. gun is capable of crashing a hundred pound projectile through fully a foot of wrought iron, one may well speculate with awe what this stupendous fellow with the 17-in. gape will do when business is on. The actual weight of the gun itself is 104 tons, and the missile it will cleave the air with turns the scale at 2000 lbs., in other words, a weight bordering on a ton. Almost needless to say, such a gun could not be employed in offensive siege work, other than on board a ship. As a matter of fact, it is a naval gun. But even this monster, ponderous as it is, is surpassed in two important respects by the 16.25 B.L. of our own country. This justly celebrated weapon throws a projectile weighing two cwt. less than the other, but has a more powerful muzzle velocity and a penetrating power superior by a couple of inches. When the cylindrical mass of deadly metal leaves the muzzle it is traveling at the rate of over 23 miles per minute. We have only to consider for a moment what this speed implies and we can then appreciate why three feet of solid wrought iron should be pierced like so much cardboard.—*United Service Gazette.*

Underwater and Overhead Fighting Craft.—No close observer interested in the accomplishments of comparatively new war machines that are being put to actual proof in this war, can have failed to come to the conclusion that there is a great opening for both overhead and underwater fighters in the wars of the future. As many men had long foreseen before the test of war was applied, submarines and aircraft have come to stay, unless, indeed, as they are developed and perfected they become so efficient that war will cease because human nature will revolt at the slaughter they may be capable of accomplishing. They have done something more than won their spurs during the first few weeks of their initial campaign. They have succeeded to such an extent that we may be sure that all the nations now at war which have facilities for producing these kinds of fighting machines, are straining every nerve in their production. Men are being trained and machines built as fast as instructors and builders can turn them out. Germany's and Britain's success with submarines will certainly prompt these countries to build larger and better vessels—for radius of action is shown to be of the greatest importance in this means of attack and defense—as fast as possible, so that as months pass and the wai remains, the strategy of attrition may be pursued with more and more persistency and enterprise. France is not likely to be less energetic in building suitable, or superior, vessels to meet and beat German productions; neither will Russia and Japan lag behind. And what is true of the policy of production for underwater craft will also be true and applicable to overhead fighting machines.—*United Service Gazette.*

Submarine and Aerial Offense in the European War.—From the technical no less than the patriotic point of view the naval actions in which this country has taken part since the war began have been of first rate interest. Nothing of sufficient magnitude has, of course, happened during the month [August] to test modern theories and modern machines of naval warfare to

any great degree. Technical interest centers chiefly on the negative results attained. Thus our fleet has been at sea facing an enemy night and day for a whole month without suffering any damage whatever from the attack of submarines. On the other hand, one of our cruiser squadrons repelled such an attack and sank one of the German submarines with apparently the greatest ease on the 9th. It would be extremely foolish to draw any hard and fast deduction from this. But it may be safely said that the submarine in actual warfare has not proved to be such a menace as peace maneuvers, and the teaching of certain experts have led us to believe. As to aircraft, we can only comment on the lack of news regarding their use by either fleet. It would be wrong, however, to assume that because there has been no news these new auxiliaries have been idle. Indeed, it will probably be found that our aircraft have played a conspicuous part in maintaining the successful vigil over the German fleet. The fact that in spite of the indiscriminate and unlicensed use by the Germans of submerged and floating mines our fleet has lost but one vessel in the course of a month by being mined is also worth noting from the technical standpoint. The action off Heligoland on the 28th seems to show that mines as well as and in conjunction with submarines do not necessarily hamper greatly the movements of a hostile fleet. It should be further noticed that a ship when mined, as was the *Amphion* on the 6th, does not always sink immediately, with the loss of all her crew. More than half of the ship's company escaped in this case.

—*The Engineer.*

*Trotyl and Submarine Mines.**—Attention has been called to the extreme violence of the explosions from German submarine attack, so that frequently the ship attacked, or a portion of it, has been literally blown to pieces. This was the case with the *Amphion*, the *Pathfinder*, and our three cruisers. On the other hand, though the *Hela* and the German destroyer sunk by our *E* 9 were small vessels, they apparently took some time to sink and their crews were saved. It is known that the Germans use tri-nitro-toluene or trotyl, and our experts were not prepared to acknowledge that it was more powerful than the various forms of picric acid, or even guncotton, used in the British service.

Before leaving the question of submarines and submarine mines, I cannot but regret that from motives of economy (it cost £500,000 a year) the admirable mine defense of our mercantile ports was given up. It was an effective deterrent against a raid such as was represented by Sir John Jellicoe's operations last year, and obviously the claim that their function could be replaced by submarines was little better than a quibble.

—*United Service Magazine.*

Moving in Mine-Sown Waters.—The fact that the First Battle Cruiser Squadron was able to take part in a sea fight so close to the minefields and principal harbors of our enemy, as they did in the action of Heligoland Bight, shows that in spite of all modern inventions a blockade attack can still be pushed home if wise precautions have first been taken. We recently discussed the possibility of protecting ships' hulls against attack by floating mines, as not being beyond the wit of our naval officers, and this battle has

* Extracted from *The Navy and the War*, by "Admiral," in *The United Service Magazine*, for November, 1914.

shown that what we predicted can be fulfilled. When once the German Fleet was in sight and our ships in chase, they wanted no better pilots to keep clear of mines than the German ships themselves; but the hazard lay in approaching the sphere of operations. The trawlers' system of sweeping must have been very effective, and even more successful than the most sanguine believer in this method of clearing the seas of such barbarous methods of attack anticipated, when an expensive fleet like a battle cruiser squadron can be trusted to use waters where these trawlers have operated at a recent date. But then, again, the ships themselves may carry some efficient contrivance, designed by their own officers, to push off any floating mine that might otherwise strike their bottom plates. Anyhow, we have evidence that our warships are not afraid to move freely about in mine-strewn waters, if it becomes necessary to risk the hazard which such movement entails, in spite of the lessons of the *Amphion* and the *Pathfinder*.

—*United Service Gazette.*

German Shells.—In view of the statements which have appeared in the Press to the effect that the destruction wrought by German shells upon fortresses in Belgium points to their possessing a secret explosive much more powerful than any known to the other European armies, a correspondent of a daily contemporary gives the warning that such rumors should be taken with a great deal of reserve. It became known some twelve months ago that Germany had adopted trinitrotoluene in the navy for high-explosive shells, torpedoes, and sea mines, and in all probability it is this substance that has caused consternation in some quarters. As an explosive, trinitrotoluene is eminently safe to handle, and needs to be detonated by mercuric fulminate, the impact of a rifle bullet even being insufficient to explode it. A shell or mine loaded with it bursts into larger fragments than when picric acid is the explosive, and although wet guncotton is more powerful if exploded in close proximity to the target, the effect produced by trinitrotoluene is much greater when the explosion takes place some distance. Whereas picric acid readily forms metallic picrates which are dangerous to handle, trinitrotoluene does not react with metals, and can be manipulated safely even when hot, as it burns slowly without exploding.—*The Engineer.*

The Value of Aeroplanes in War.—In all of his reports Gen. French has laid stress upon the great service rendered by the aviators in ascertaining the moves of the enemy as soon as they start to make them. The reconnaissance work they have performed has been invaluable. According to the official statement of the British War Office, their aviators are covering an average of 2000 miles a day. Up to September 21st they had flown 87,000 miles and remained 1400 hours in the air. By now these figures have been doubled. A certain French corps commander's opinion is that a single aeroplane is as valuable as an entire division of cavalry.

—*Scientific American.*

Bombs for Aeroplanes.—Successful experiments in dropping bombs from aeroplanes at the Army aero station at San Diego, Cal., are reported to the War Department. A new type of aero bomb produced by the Ordnance Department and an aeroplane range finder invented by Riley E. Scott, a former U.S. Army Artillery officer, were used in the experiments, which it

is believed will increase the effectiveness of attacks from aeroplanes. The bombs, which were of two sizes, fifteen and fifty pounds, were equipped with adjustable fuses. Until it is set the bomb can be handled with perfect safety. In dropping from an aeroplane the bomb is slipped down into a net below the machine, with a string attached to the fuse. The aviator then pulls the string attached to the fuse, which "loads" or arms (as ordnance officers express it) the bomb. This is done just before the net is opened and the bomb dropped. The Scott range finder is telescopic and indicates just when the bomb should be dropped in order to strike the target. It does this by estimating the speed of the machine and its height above the ground. With all of the attention that the European armies have been giving to aeroplanes and Zeppelins, none of them has developed are liable range finder. Most of the bombs dropped have been guided only by a judgment of distances and estimates on the speed of aeroplanes without the aid of any instruments. This, it is stated, accounts for the inability of any of the Powers in the present war to do much effective work with bombs at high altitude. The maximum height at which the tests were made at San Diego was 2500 feet, but the accuracy with which the bombs dropped indicates that the Scott range finder is a success and will enable military aviators with proper training to do effective work at a height of 5000 feet. This would place aeroplanes out of the range of small arms and most of the field artillery guns. The bombs, containing high explosives, tore great holes in the hard soil six and seven feet in diameter and three of four feet deep.—*Army and Navy Journal.*

Aerial Mining.—According to a member of the Army General Staff at Washington, it is entirely feasible to "mine" the air above fortifications against attacks by dirigibles and aeroplanes. The expert's plan of defense is analogous to the mining of marine approaches to ports, and consists of sending aloft each evening a large number of small captive balloons at varying altitudes carrying a sufficient amount of explosive to destroy the aeroplanes or dirigibles with which they come in contact. These balloons can be supplemented by a number of kites provided with long tails of malleable wire, designed to foul the propellers of any aircraft. The aerial mines could be reeled in at daybreak.—*The Engineer.*

New High-Power Explosive.—Tests were recently made in the presence of a number of contractors and business men of Vancouver of a new explosive called sabulite, which will be manufactured at Coquitlam, British Columbia. A company capitalized at $300,000 has been organized to handle the product, and a plant for its manufacture is nearing completion.

Experiments were made in blasting stumps, in which comparative estimates of the power of the new material were made with the explosive force of dynamite, and it is claimed that 6½ pounds of sabulite is equal to 20 pounds of dynamite in destructive effect.

The chief feature of sabulite is that it can be handled without danger, both while in course of manufacture and in use. None of the ingredients are in themselves explosive. Sabulite is not affected by heat or cold. It has been subjected to a temperature of 258 degrees Fahrenheit and 75 degrees below zero without its properties being affected. Another salient point about the explosive is that no poisonous fumes are given off in the explosion, only a slight odor being perceptible at the tests made here.

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While the quantity of sabulite required for ordinary purposes is only about one-third that of dynamite, the cost of production per pound is said to be about the same. Sabulite is used for blasting purposes only.

—*Army and Navy Register.*

The "California" Class of Battleships.—Although the three battleships of the "California" class, an illustration of which was given in our issue of September 26th, are practically identical with the *Pennsylvania* and *Arizona*, it has been decided to give them a separate class name. The *Pennsylvania* and *Arizona* will have the usual ram bow, which they were designed to carry. The "California" class, which will be known as the *California*, the *Idaho*, and the *Mississippi*, will be distinguished from them by carrying the clipper bow * * * *.

It has been the broad policy of our navy to build our battleships in classes of five each, so that the active fleet in commission will consist of divisions of four ships in active service with the fleet, the fifth ship being at the navy yard for its annual overhauling. The *California* and the *Pennsylvania* will be practically identical in size, speed, armor protection, and armament, and, therefore, they will form a group having the same speed and general maneuvering qualities. Although, when they are all completed, they will be alike in all military particulars, it will be easy to distinguish the two classes by the shape of the bow.—*Scientific American.*

Highways for Coast Defense.—The Detroit Free Press, referring to the subject of the inadequacy of our coast defense, asks: "Why not create coastal military roads extending from our northern to our southern frontiers and joined across the continent by what might be made a development of the present Lincoln highway project? With these roads in commission," it says, "the nation might substitute for its present isolated coast defenses a constantly movable shore fleet of huge coast defense guns mounted on automobile trucks which could be mobilized almost as swiftly as ships in any area that might need protection. With such a system of coast guarding in operation the United States would have a second line of defense behind its Navy that would make it practically invulnerable from the sea and at a comparatively reasonable outlay. Though the highways would necessarily be constructed under the direction of the War Department and must remain under Federal control no matter whether the states or the nation paid the first cost, in times of peace they could be employed constantly for commerical purposes. They would be available as great trunk lines like the Grand Trunk road of India and along them could be developed an automobile carrier traffic whose extent can scarcely be estimated, at a time when the use of the motor car as a commercial agent is constantly in the increase and its capacity for development apparently boundless. There are persons who rail against the development of our military and naval resources on the ground that we are first of all in need of good roads. Well, here may be a chance to combine military prudence with economic advance."

—*Army and Navy Journal.*

BOOK REVIEWS

The Foundations of Strategy. The "Special Campaign" Series. By Captain H. M. Johnstone, R. E., Ret., Military Lecturer to Edinburgh University. London: George Allen and Unwin, Ltd., 44 Rathbone Place, W.; New York: The Macmillan Company. 5" x 7½" 208 pp. 10 maps. 1914. Price, 5 shillings net.

In his preface the author states, "Foundations are broad and solid, but do not exhibit much detail"; and his development of his subject, "The Foundations of Strategy," is consistent therewith. Indeed, if the work have a fault it is that—lack of sufficient detail to enable one intelligently to study it without reference to a work of greater detail.

The technical phrase which the author has adopted as best expressing his conception of the fundamental principle of strategy is "full strength," the comprehensive meaning of which, as he uses it, we glimpse from the following explanatory statements: "The best thing is to have as much as you can for yourself, and as little as you can for the enemy, even if actual preponderance of numbers is impossible." "Strength and force are, it is recognized, far from being a mere matter of numbers. If training, discipline and organization are equal, there still remains the paramount matter of *moral.*" "This phrase, again, does not mean that the commander must have every one of his units on the spot, regardless of all other considerations; but it does mean that every consideration that is allowed to deduct from strength at the scene of the battle, or from strength at the place and time of the crisis of the decisive attack of the battle, shall be a consideration that has an assignable and an adequate bearing upon the success of the battle."

As sub-principles flowing from his master principle, the author enumerates initiative, intelligence (information), mobility (including organization, training, and discipline), knowledge of physical features of the theatre, selection of objective, moral factors, and sea power.

The author has divided his work into two parts, the first of which, devoted to general principles, he calls the statical, and the second, devoted to typical movements, he calls the dynamical.

The fourteen chapters of Part I follow closely the sub-principles enumerated, and are as follows: Offensive and defensive; Base of operations and line of communications; "Full strength;" Seizure and retention of the initiative; Intelligence; Mobility; Importance of organization and value of numbers; Training—its influence on strategy; Discipline; Physical features of a theatre of war; Selection of an objective; Naval factors in war; Politics; and The influence of fortresses.

Part II is composed of six chapters, as follows: The opening of a campaign; Strategical frontal attack on a single enemy; Strategical attack on two or more enemies; Turning a flank; Placing an army on the enemy's communications; and Sea power.

The points of discussion are well made and forcefully illustrated, the whole work abounding in apt references to the great battles of the world.

There are passages in the work which, written for Great Britain, apply equally to the United States: "The passage from peace footing to war footing should entail no dislocation of existing units." "The British organization problem is a specially difficult one. Half of the regular army is perforce abroad, and we still depend on voluntary enlistment. The people do not yet realize the gravity of the menace of a foreign 'Nation in Arms.' A truly national army is found where the nation is so educated in a polictical sense that its able-bodied men are, *as a matter of course*, trained soldiers, each man having served for a continuous period, long enough to make him a trained soldier."

The chapter (VIII) on Training should be printed in pamphlet form and distributed by the National Defense League, it is so pertinent to conditions in the United States.

The agreement of the predictions of strategists made during recent years with current happenings in Europe, is again instanced in the work under review; and the first chapter of Part II, "The Opening of a Campaign," is especially interesting at this time, discussing, as it does, the German doctrine of immediate deployment for "a sweeping advance on a broad front," and the French doctrine of delay to get reports of the enemy's action, followed by movement "on a narrow front with a great depth." Of the French doctrine, the author says: "The formation is good enough if the commander has the resolution to keep the initiative, and to force the enemy to conform to his actions. Granted this character in the French chief, the "German" method might lead to grave inconveniences owing to the notorious difficulty of effecting a fresh grouping in an army already fully deployed."

On page 25 the author makes the mistake of representing a study of strategy in the present as inconsistent with the hope of cosmopolitanism and a fuller Christianity in the future. Despite its incidental philosophy, or national ethics, however, *The Foundations of Strategy* may be recommended because of its sound strategical principles.

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Army Orders. By Captain J. A. Moss, U. S. Infantry. Sales Agents: George Banta Publishing Company, Menasha, Wisconsin; Post Exchange, Fort Wm. McKinley, P. I. 5½" x 7¾". 652 pp. Cloth. 1914. Price, $3.00 postpaid.

Very appropriately the author has designated his work a residuum for it presents to the reader only such general orders and circulars as are still in force, every order and circular that has the nature of special orders, that has expired with execution, "been revoked, superseded, nullified or incorporated in Army Regulations, Drill Regulations, Equipment Manuals or any other War Department publication" having been discarded. "In the case of the general orders every paragraph of every order omitted has been accounted for, so that the numbers, therefore, follow one another serially."

The value of the volume depends, of course, on the scheme or system followed in its preparation, the thoroughness of the work, and the handiness of the resultant book.

The first and the last the reviewer can commend without reservation—the scheme is good and the volume convenient—in 50 cubic inches weighing

$1\frac{1}{2}$ lbs. one has the live matter of 2000 cubic inches of general orders weighing 53 lbs.

The thoroughness of the work, however, cannot be determined in a review; for, from the very nature of the work, the determination of that is a question of daily use in an administrative office during some length of time.

Here though, the author's reputation established through other works that have commended themselves to the service assures one that in *Army Orders* one is supplied a helpful administrative tool.

A new edition is promised annually.

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The Round Table. A quarterly review of the politics of the British Empire. No. 16. Special war number. New York: The Macmillan Company, 66 5th Ave. 6″ x $9\frac{1}{2}$″. 210 pp. 1 map. 1914. Price per copy, 2/6.

The special war number of the *Round Table* is a journalistic, or magazine, contribution to the literature of the great European war of 1914 that is of far more than ephemeral interest. The articles are analytical and philosophical in charater and as dispassionate as is probably humanly possible.

The number includes the following articles: The War in Europe (origins, the critical fortnight, ultimate issues); Germany and the Prussian Spirit (German idealism, the Prussian autocracy, the strong wine of victory, Bismarck's legacy, bureaucracy and militarism, the religion of war, 1914); The Austro-Servian Dispute (the assassination of the archduke, the crises of 1908 and 1912, the Austro-Hungarian ultimatum); Lombard Street in War; United Kingdom (the Nationalist volunteers, the amending bill and the king's conference, an involved problem); The White Book Summarized; and Sir Edward Grey's Speech, August 3.

The volume is recommended to all students of the causes and circumstances of the war.

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Neutral Nations and the War. By J. Bryce. New York: The Macmillan Company, 66 5th Ave. $5\frac{1}{2}$″ x $7\frac{3}{4}$″. 16 pp. 1914. Paper. Price, 20 cents.

Without violation of the neutral spirit, a neutral may commend the pamphlet, *Neutral Nations and the War*, by James Bryce, an eminent subject of one of the belligerent governments; for the pamphlet is not partisan, but philosphical. And its philosophy is not hung upon a supposed fault in a nation with which the author's government is at war, but is simply addressed to the refutation of what must be recognized by all Christians as erroneous statements of principle—the statements by which Bernhardi, in his *Germany and the Next War*, endeavors to support his individual philosophy of war.

It can but be gratifying to citizens of the United States to find cited (page 12) as instances of magnanimity on the part of the Anglo-Saxon race, the action taken by the United States Government in its relations with Cuba and Mexico.

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Training Infantry. By Colonel John F. Morrison, U. S. Infantry. Fort Leavenworth, Kansas: U. S. Cavalry Association. 5" x 7½". 187 pp. Paper. 1914. Price, postpaid, 60 cents.

This is an excellent work: it advocates correct theory; it sets forth practical methods; and it is pervaded with a spirit of honor and patriotism.

Some of the means proposed are radical, it is true, as for instance, in Chapter XI, "Recruiting." But the author gives, of methods proposed, outlines sufficient to convince the reader that they are practicable and have advantages.

The work contains twelve chapters, the contents of which are suggested by the following headings: I. The Essential and the Desirable; II. General Distribution of Time; III. Fire Superiority; IV. Combat; V. Artillery Fire; VI. Patrols, etc.; VII. Marching; VIII. The National Guard; IX. Inspections; X. Training a New Regiment; XI. Recruiting; XII. Relative Values.

All the chapters are so helpful that no officer, either in the Regular Service or the National Guard, who is concerned with infantry training can afford to be without the work—captains, majors and colonels especially requiring it.

In Chapter X, "Training a New Regiment," the author sets forth a plan, and even a schedule, for the preparation of a regiment of volunteers for service in three months; and one on reading it is convinced that it affords an excellent working basis—not for a perfect solution of an almost impossible problem, but for a practical way of meeting a "condition."

In the chapter on "Recruiting," the author proposes localization for recruiting purposes only, and suggests a five-year enlistment made up of one year in service and four years on "furlough."

The most valuable and instructive part of the work is, naturally, that devoted directly to training; and it all seems so simple and interesting that one is led to wonder how the duty is ever rendered disagreeable and difficult in performance. May not the answer be found in the spirit in which supervision and inspection are exercised or carried out? At any rate, in Chapter IX the author suggests the question. A spirit of hostile criticism on the part of a superior or inspector, or the more common disire to demonstrate one's superiority by finding something wrong, tends to cramp initiative and stifle efficiency, whereas a spirit of cooperation and helpful instruction lends nimbleness to thought and inspires effort. The country needs the good that may be derived from a sympathetic attitude toward the line on the part of commanders and staff.

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The Principles of War, Vol. I. (Military Textbook Series.) By Major-General E. A. Altham, C. B., C. M. G. London and New York: Macmillan and Company, Limited. 1914 6" x 9". 436 pp. 5 maps. Price, $3.50.

This work comprises seventeen chapters, 425 pages, exclusive of the index and a separate volume of five maps. It is printed in clear, bold type on good paper.

Chapter I, "The Factors of Success in War," is an analysis of conditions leading to success in war, and historical illustrations from the United States

Civil, Franco-Prussian, South African, Russo-Japanese, and Balkan Wars are used.

Chapter II, "The Organization of a Field Army," deals largely with recent developments applied to the British army.

In Chapters III and IV, "The Characteristics of Fighting Troops, Cavalry and Other Mounted Troops," is a review of the use of cavalry from Seidlitz to Akiyama. Mounted infantry and cyclists also are included.

Chapter V, "The Royal Flying Corps," refers particularly to the organization and use of the British flying corps.

Of Chapters VI and VII, "The Artillery," Chapter VII relates particularly to the use of artillery in the Russo-Japanese War.

Chapter VIII, "Engineers," treats of their organization, equipment, and use.

Chapters IX, X, and XI, "Infantry," include important historical illustrations from Frederick the Great to Matsunaga.

Chapter XII, "Machine Guns," includes examples from Mars-La Tour to Mukden.

Chapter XIII, "Means of Communication," refers particularly to modern developments.

Chapter XIV, "Intercommunication of Orders," presents illustrative and historical examples from the Napoleonic to the Russo-Japanese Wars.

Chapters XV and XVI, "Movements by Land and Sea," include discussion of principles involved and other illustrations from the Franco-Prussian and Russo-Japanese Wars.

In Chapter XVII, "Billets and Bivouacs," the lessons are drawn principally from the Franco-Prussian War.

The volume of maps includes the following: Campaign in Manchuria, the Yalu, Liao-Yang, Sha-Ho, Strategical map.

This work is a most successful attempt to illustrate by the study of campaigns, particularly more recent ones, the principles set forth in British Field Service Regulations, Part I. The controlling consideration in its preparation, apparently, has been to assist officers in their preparation for field service. In his introduction to the treatise General Sir Horace L. Smith-Dorrien, G. C. B., D. S. O., A. D. C. General, says: "Not only is such an excellently arranged treatise invaluable to young students struggling to master the art of war and pass their promotion examinations, but equally so to a senior officer who, in the course of instruction, say, at a conference, is rubbing in a principle and is at a loss for an example from history to drive it home."

The text is written in an easy style and in language not too technical for the layman. The development of each important principle discussed is pursued so logically and illustrated so forcibly that one cannot help retaining much of value on a first reading.

Chapter I, "The Factors of Success in War," is alone worth the price of the book, not only to the professional soldier but equally so to any private citizen interested in the welfare of his country, and most particularly to those of our citizens who are responsible to the nation for its preparation for war and who may not fully realize "that preparation for war is a national duty, the neglect of which involves humiliation and disaster," as taught by the lessons of our own Civil War, the Franco-Prussian, Russo-Japanese, and Balkan Wars.

Wherever practicable, the illustrative historical method is used throughout the text. The *ipse dixit* method of instruction is not used.

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Taschenbuch der Kriegsflotten, 1914-15. By B. Weyer, Kapitanleutnant, a.D. Munchen, Germany: J. F. Lehmann's Verlag. 5" x 6¾". 425 pp. Cloth. Numerous illustrations. 1914. Price, M 4.50.

The war number of the Handbook of Navies, by Weyer, has just been issued: and while the general plan of previous editions has been adhered to, yet the omission of several customary sections is noted. Also, all data relative to German and Austro-Hungarian ships have been excluded, at the request of the German naval authorites, for alleged obvious reasons. No doubt the absence of some of the usual information is due to the circumstances under which the present number has been prepared: the author having offered his services to the fatherland at the outbreak of hostilities, the preparation of the work for the printer has been accomplished by the publisher alone.

Part I, pp. 6-353, comprises a detailed list of foreign warhips, probable auxiliary urcisers of the great naval powers, and photographic views and plans, as well as silhouettes, of the ships mentioned. In this section is found definite information as to the offensive and defensive characteristics of the ships, such as guns, armor, torpedoes, total weight comprised in a broadside, speed, steaming radius, fuel carrying capacity, crew, kind and power of engines installed, etc.

Part II, pp. 354-397, is devoted to the naval artillery of the fleet, and gives the caliber of guns in cm., length of guns in caliber, official designation and weight of guns, muzzle velocities, maximum rate of fire per minute, and maximum penetration of Krupp armor at certain ranges for different guns. In this section is found also a list of firms manufacturing naval and coast guns, information relative to the guns, and a list of other plants for the production or repair of munitions of war of the larger naval powers, such as naval repair shops, docks (both governmental and private), armor-plate plants, torpedo factories, and factories of artillery material in general.

Part III, pp. 398-425, contains the usual conversion tables for measures and weights, a calendar for 1914-15, and an alphabetical index of the contents of the book, followed by an alphabetical index of all the warships mentioned.

While this war number of the Handbook of Navies has excluded from it all data relative to the German and Austrian warships, the information given relative to the other navies is exact in the minutest detail. The compilation includes data available up to the middle of August, 1914, and pertains to completed ships.

To those who are familiar with the previous editions of the handbook, the present number will prove a valuable guide.

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Index to Current Military Literature

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KEY

TO

INDEX TO CURRENT MILITARY LITERATURE

The periodicals cited are arranged by government, and each periodical is assigned a symbol consisting of an initial, or other abbreviation of the governmental designation, and a numeral indicative of the periodical's position in an alphabetical arrangement of the JOURNAL OF THE UNITED STATES ARILLERY's exchanges under that government.

Prices of subscription are given in the currencies of the countries of publication.

All the periodicals cited are preserved in the Library of the Coast Artillery School at Fort Monroe, Virginia.

ARGENTINE

Ar–0.5	*Anuario del Instituto Geografico Militar de la Republica Argentina*	
	3^a Division del Estado Mayor del Ejército	Annual
	Buenos Aires	
Ar–1	*Boletin del Centro Naval*	Bimonthly
	Florida 659,	Per year $\$^{m}/_{n}11.90$
	Buenos Aires	
Ar–2	*Revista Militar*	Monthly
	Ministerio de Guerra, Santa Fe 1461	Per year $\$^{m}/_{n}9.00$
	Buenos Aires	

AUSTRIA

Au–1	*Mitteilungen aus dem Gebiete des Seewesens*	Monthly
	Pola	Per year 17 M
Au–2	*Mitteilungen ueber Gegenstaende des Artillerie-und Genie-Wesens*	
	Getreidemarkt 9	Monthly
	Wien, VI.	Per year 20 M
Au–3	*Streffleurs Militaerische Zeitschrift zugleich Organ der militaerwissenschaftlichen Vereine*	Monthly
	I. Graben, 13. Wien	Per year 28 M
Au–3.5	*Streffleurs Militaerblatt*	
	Verlag L. W. Seidel & Sohn, k.u.k	Weekly
	Hofbuchhandler, Wien	Per year 16 M
Au–4	*Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*	
	I. Eschenbachgasse, No. 9	Weekly
	Wien	Per year 34 K

BELGIUM

Be–1	*Belgique Militaire, La*	Weekly
	Rue Albert de Latour 50	Per year 12 fr 50
	Schaerbeck, Brussels	
Be–2	*Revue de l'Armée Belge*	Bimonthly
	24 Rue des Guillemins, Liege	Per year 13 fr

Be-3	*Revue de l'Ingénieur et Index Technique* 70, Boulevard d'Anderlecht, Brussels	Quarterly Per year 30 fr

BRAZIL

Br-1	*Boletim Mensal do Estado Maior do Exercito* Ministerio de Guerra Rio de Janeiro	Monthly
Br-2	*O Tiro* Rio de Janeiro	Monthly
Br-3	*Revista Maritima Brazileira* Rua D. Manoel n. 15 Rio de Janeiro	Monthly Per year 12$000

CHILE

C-1	*Memorial del Estado Mayor del Ejercito de Chile* Talleres del Estado Mayor-General Santiago	Monthly
C-2	*Revista de Marina* Casilla del Correo 976, Valparaiso	Monthly Per year $15.00

COLOMBIA

Co-1	*Memorial del Estado Mayor del Ejercito de Colombia* Jefe del Departamento de Historia del Estado Mayor-General Bogota	Bimonthly Per year $0 50 oro

DENMARK

D-0.5	*Dansk Artilleri-Tidsskrift* Copenhagen	Bimonthly Per year 5 kr
D-1	*Militært Tidsskrift* Copenhagen	Semimonthly Per year 8 kr

DOMINICAN REPUBLIC

DR-1	*El Porvenir Militar* Salome Urena No. 8 Santo Domingo	Monthly

FRANCE

F-1	*Archives Militaires, Les* Librairie Militaire Berger-Levrault 5-7 Rue des Beaux-Arts, Paris	Quarterly Per year 14 fr
F-2	*France Militaire, La* 10 Rue Danton, Paris	Daily Per year 32 fr
F-3	*Génie Civil, Le* 6 Rue de la Chaussée d'Antin, Paris	Weekly Per year 45 fr
F-4	*Journal des Sciences Militaires* 30 Rue Dauphine, Paris	Weekly Per year 40 fr
F-5	*Liste Navale Francaise* Quai Cronstadt, au coin de la Rue Neuve Toulon	Quarterly Per year 9 fr
F-6	*Mémoires et Travaux de la Société des Ingénieurs Civils* 19 Rue Blanche Paris	Monthly Per year 36 fr

F-7	*Mémorial des Poudres et Salpetres*	Semiannual
	55 Quai des Grands-Augustins, Paris	Per year 13 fr
F-8	*Mois Scientifique et Industriel, Le*	Monthly
	8, Rue Nouvelle, Paris	Per year 25 fr
F-9	*Monde Militaire, Le*	Fortnightly
	6 Rue de la Chaise, Paris	Per year 6 fr
F-10	*Revue d'Artillerie*	Monthly
	5 Rue des Beaux-Arts, Paris	Per year 22 fr
F-11	*Revue de Cavalerie*	Monthly, ex. Aug.
	5 Rue des Beaux-Arts, Paris	Per year 27 fr
F-12	*Revue du Génie Militaire*	Monthly
	5 Rue des Beaux-Arts, Paris	Per year 27 fr
F-13	*Revue d'Infanterie, La*	Monthly
	10 Rue Danton, Paris	Per year 25 fr
F-14	*Revue Maritime*	Monthly
	30 Rue et Passage Dauphine, Paris	Per year 36 fr
F-15	*Revue Militaire des Armées Etrangères*	Monthly
	Librairie Chapelot	Per year 15 fr
	30 Rue et Passage Dauphine, Paris	
F-16	*Yacht, Le, Journal de la Marine*	Weekly
	55 Rue Chateaudun, Paris	Per year 32 fr

GERMANY

G-1	*Artilleristische Monatshefte*	Monthly
	Bernburgerstr. 24-25 Berlin, S. W. 11	Per year 27 M
G-2	*Eisen-Zeitung*	Weekly
	Verlag von Otto Elsner, Berlin, S. 42	Per year 12 M
G-3	*Ingenieur, Der*	Semimonthly
	Verlag Buchdruckerei F. Posekel,	Per year 16 M
	Gneisenaustrasse 67, Berlin S. 61,	
G-3.5	*Kriegstechnische Zeitschrift*	10 Nos. per yr.
	E. S. Mittler & Sohn	Per pear 10 M.
	Königliche Hofbuchhandlung,	
	Kochstrasse, 68-71, Berlin, S. W.	
G-4	*Marine Rundschau*	Monthly
	Koch Strasse, 68-71, Berlin, S.W.	Per year 10 M
G-5	*Militaer Wochenblatt*	3 times a week
	With monthly Supplement	Per year 18 M
	Koch Strasse, 68, Berlin, S.W., 12	
G-6	*Schiffbau*	Semimonthly
	Zimmerstr. 9, Berlin, S.W., 68	Per year 20 M
G-8	*Ueberall*	Monthly
	Verlag: Boll und Pickardt	Per year 15.6 M
	Berlin, N.W. 7	
G-9	*Zeitschrift fuer das Gesamte Schiess-und Sprengstoffwesen*	
	J. F. Lehmann's Verlag, Paul Heysestrasse 26,	
	Munich	Semimonthly
		Per year 26 M

HOLLAND

H–1	*Orgaan der Vereeniging ter beoefening van de Krijgswetenschap*	
	Z. O. Buitensingel 224	Six Nos. per yr.
	The Hague	Per year 4 florins
H–2	*Wetenschappelijk Jaarbericht. Vereeniging ter beoefening van der Krijgswetnschap*	
	Z. O. Buitensingel 224	Yearly
	The Hague	Per year 2 florins

ITALY

I–1	*Lista Navale Italiana*	Quarterly
	Officina Poligrafica Italiana, Rome	Per year 15 L
I–2	*Rendiconti delle Esperienze e Degli Studi Eseguiti Nello Stabilimento di Esperienze e Costruzioni Aeronautiche del Genio*	
	Viale Giulio Cesare N. 2, Rome	Occasional
		Per year 13.50 L
I–3	*Rivista di Artiglieria e Genio*	Monthly, ex. July
	Tipografia Enrico Voghera	Per year 20 L
	Via Astalli 15, Rome	
I–4	*Rivista Marittima*	Monthly
	Officina Poligrafica Italiana	Per year 25 L
	Rome	

MEXICO

M–1	*Boletin de Ingenieros*	Monthly
	War Dept., Mexico City	
M–2	*Revista del Ejercito y Marina*	Monthly
	Departamento de Estado Mayor	
	City of Mexico	

NORWAY

N–1	*Norsk Artilleri-Tidsskrift*	Bimonthly
	Christiania	Per year 6 kr
N–2	*Norsk Militært Tidsskrift*	Monthly
	Christiania	Per year 8 kr

PERU

Pe–1	*Boletin del Ministerio de Guerra y Marina*	Fortnightly
	Apartado de Correo No. 91, Lima	

PORTUGAL

Po–1	*Anais do Club Militar Naval*	Monthly
	43 Rua do Carmo, Lisbon	Per year 4$200
Po–2	*Revista de Artilharia*	Monthly
	Rua do Carmo, 43, 2°., Direito, Lisbon	Per year 3$000 rs
Po–3	*Revista de Engenharia Militar*	Monthly
	27 Rua Nova do Almada, Lisbon	Per year 3$600 rs
Po–4	*Revista Militar*	Monthly
	Largo da Annunciada, 9, Lisbon	Per year 3$000 rs

RUSSIA

R–1	*Imperial Nicholai War Academy Recorder, The*	Monthly
	St. Petersburg	Per year 6 rubles

R-2	*News of the Officers' Artillery School*	Monthly
	Zarskoye Selo	Per year 10 rubles

SPAIN

Sp-1	*Informacion Militar del Extranjero*	Monthly
	Talleres del Deposito de la Guerra	
	Madrid	
Sp-2	*Memorial de Artilleria*	Monthly
	Museo de Artilleria, Madrid	Per year 18 ps
Sp-3	*Revista Cientifico-Militar*	Semimonthly
	Guerra Europea, La	Weekly
	Paseo de San Juan, 201, Barcelona	Per year 40 ps
Sp-4	*Revista General de Marina*	Monthly
	Ministerio de Marina, Madrid	Per year 25 ps

SWEDEN

Sn-1	*Artilleri-Tidsskrift*	Bimonthly
	Artillerigarden, Stockholm	Per year 6 kr
Sn-2	*Svensk Kustartilleritidskrift*	Quarterly
	Karlskrona	Per year 6 kr

SWITZERLAND

Sd-1	*Allgemeine Schweizerische Militarzeitung*	Weekly
	Basel	Per year 10 fr
Sd-2	*Revue Militaire Suisse*	Monthly
	Avenue Juste Olivier, Lausanne	Per year 15 fr
Sd-3	*Schweizerische Monatschrift fuer Offiziere Aller Waffen*	
	Frauenfeld	Monthly
		Per year 5 fr
Sd-4	*Schweizerische Zeitschrift fuer Artillerie und Genie*	
	Frauenfeld	Monthly
		Per year 8 fr

UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ITS COLONIES AND POSSESSIONS

UK-1	*Arms and Explosives*	Monthly
	Effingham House	Per year 7s
	Arundel Street, Strand, London, W.C.	
UK-3	*Army Review, The*	Quarterly
	Wyman & Sons, Ltd.	Per copy 1s
	Fetter Lane, London, E. C.	
UK-3.5	*Australian Military Journal, The*	Quarterly
	Melbourne, Australia	Per copy 1s
UK-4	*Canadian Military Gazette*	Semimonthly
	Room 16, Trust Bldg.	Per year $2.50
	Ottawa, Canada	
UK-6	*Electrician, The*	Weekly
	1, 2 and 3, Salisbury Court, Fleet Street	Per year 30s
	London	
UK-7	*Electrical Review*	Weekly
	4, Ludgate Hill, London, E. C.	Per year £1 10s

US-65	*Scientific American* 361 Broadway, New York	Weekly Per year $3.00
US-66L	*Scientific American Supplement* 361 Broadway, New York	Weekly Per year $5.00
US-68	*Seventh Regiment Gazette, The* 30 West 33rd Street, New York	Monthly Per year $1.50
US-71	*Stevens Indicator* Stevens Institute of Technology Hoboken, N. J.	Quarterly Per year $1.50
US-73	*Telephone Engineer* Monadnock Building, Chicago, Ill.	Monthly Per year $2.00
US-74	*Transactions of the American Society of Civil Engineers* 220 West 57th Street, New York	Yearly Per year $12.00
US-75	*Transactions of the Society of Naval Architects and Marine Engineers* 29 West 39th Street, New York	Annual
US-76L	*Virginia Magazine of History and Biography, The* Virginia Historical Society Richmond, Va.	Quarterly Per year $5.00

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US-65	*Scientific American* 361 Broadway, New York	Weekly Per year $3.00
US-66L	*Scientific American Supplement* 361 Broadway, New York	Weekly Per year $5.00
US-68	*Seventh Regiment Gazette, The* 30 West 33rd Street, New York	Monthly Per year $1.50
US-71	*Stevens Indicator* Stevens Institute of Technology Hoboken, N. J.	Quarterly Per year $1.50
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A chart for finding "C"—US-38, September-October, 14.

Notes on ballistics (small arm rifle). Setting of the sight—D-0.5, September, 14.

Projectile photography—US-66L, October 17, 14.

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The theory of the hyperbolic error and its utilization for ballistics—Au-2, August, 14.

Some ballistic conceptions—Br-2, June, 14.

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The fireproof storage of inflammable and explosive liquids—Au-2, October, 14.

Production of explosives in the United States—US-15, Technical Paper No. 85.

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The Von Löbell reports on military matters in 1913—US-37, November-December, 14.

Notes on the development and use of fortification in the field—UK-14, July, 14.
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2. Seventy-five dollars for the best essay, determined as above, on the other subject named—that is, on the subject not discussed in the essay to which the first prize is awarded—except as provided under condition (b).

SUBJECTS

A. Coast Artillery Target Practice: Its Purpose and How Best to Accomplish It.

B. The Tactics of Harbor Defense, Including a Discussion of Plans for Defense Against Naval Attack and Orders for Carrying Them Into Effect.

CONDITIONS OF THE COMPETITION

(a) Competition will be open to all readers of the Journal.

(b) Award will be made by a committee of award, consisting of three persons, to be nominated by the Coast Artillery School Board. If no essay submitted seems to the committee worthy of a prize, none will be awarded. If it appears to the committee that no essay fulfills the conditions for the second prize, but that another essay upon the same subject as that of the first prize essay is worthy of the second prize, they may award the second prize to that essay. Honorable mention may

be made of any essay submitted, which seems to the committee worthy thereof, but to which a prize is not awarded.

(c) Manuscript must be submitted in triplicate. It must contain nothing to indicate its authorship, must be signed with a *nom de plume* and must be accompanied by a sealed envelope containing this *nom de plume* and the name of the writer. This envelope will remain in the hands of the Editor of the Journal and, after award has been made by the committee, will be opened in the presence of the Coast Artillery School Board.

(d) All essays to which prizes are awarded, or of which honorable mention is made, will become the property of the Journal of the United States Artillery. These will be published, if approved by the Coast Artillery School Board. All others will be returned to their authors.

(e) All essays must be typewritten, with lines double spaced, on one side of the paper only. No essay shall contain more than 15,000 words, exclusive of tables (about 40 pages of the Journal). Manuscript must be received on, or before, December 31st, 1914. It must be addressed Journal U. S. Artillery and the envelope must bear the notation, "Essay Competition."

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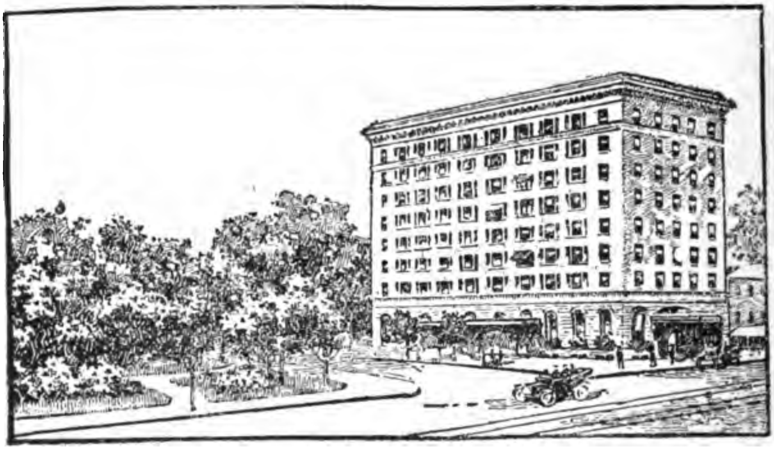

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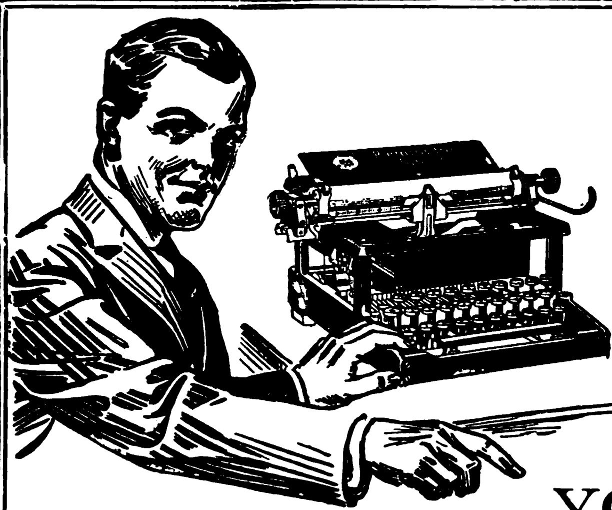

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